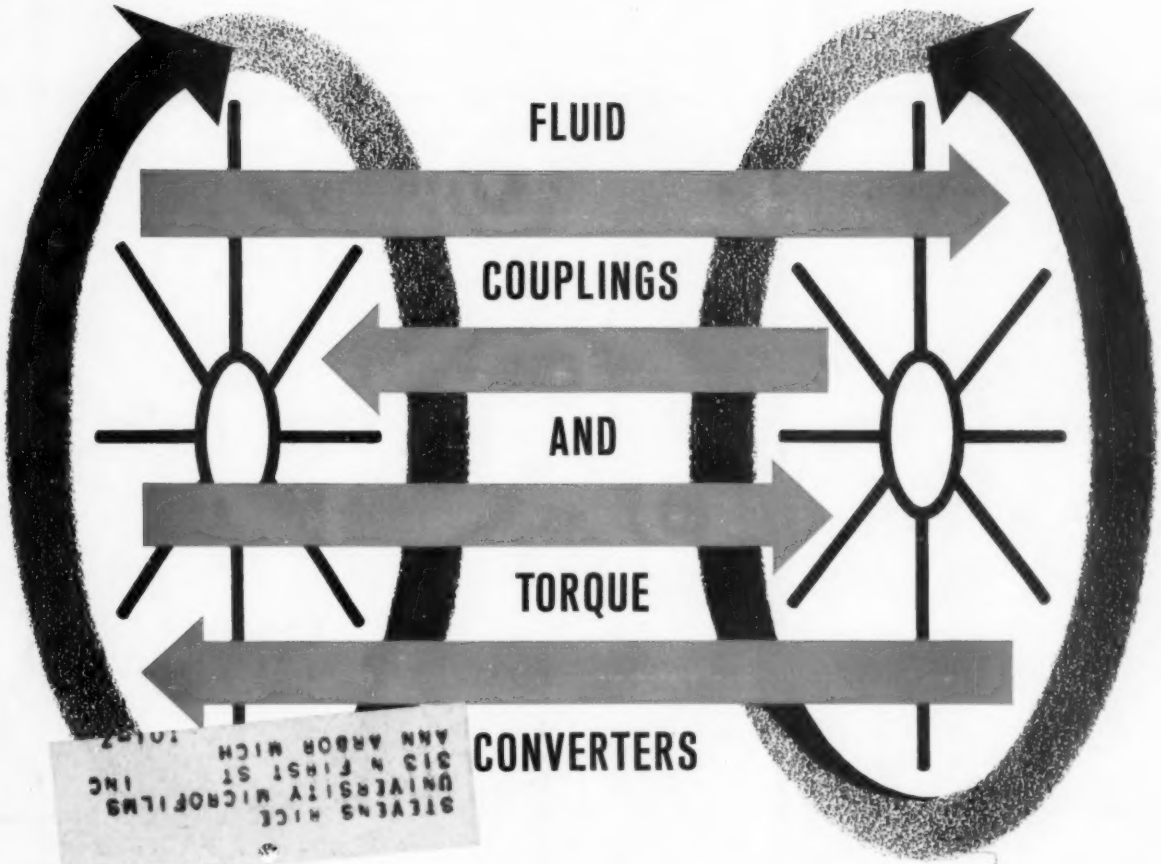
POWER TRANSMISSION DESIGN

AUGUST 1960

MACHINE DRIVES & COMPONENTS



ALSO IN THIS ISSUE:

Determining bearing loads from right-angle gears

Air clutches accommodate shaft elongation

INCLUDING BEARINGS DESIGN / APPLICATION

Read by 40,000 men who specify power transmission products for original equipment and in-plant applications

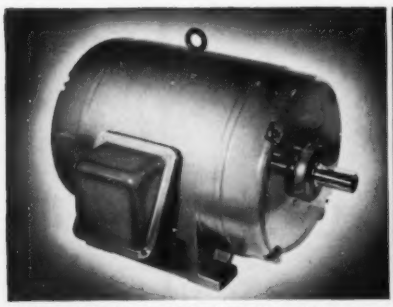
Sudden Splash or Soaking Shower

won't stop a Wagner® DP Motor . . .

Wagner® Type DP Motors are doubly protected by rugged, corrosion-resistant cast iron frames and dripproof enclosures. Splashing or falling liquids, corrosive acids, salts, and alkalies can't stop their smooth operation. Designed to meet a wide variety of applications—including many that used to require splashproof motors—Wagner Doubly Protected Motors pack plenty of power into precious little space, are lightweight, long-lived, and pare downtime and upkeep costs to the bone. Simply put . . . they get the job done. Let your nearby Wagner Sales Engineer show you how these motors can be applied to your needs. Call him, or write for Bulletin MU-223.

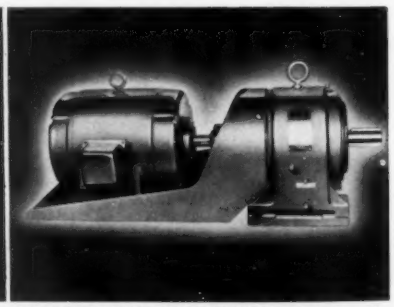
Wagner Electric Corporation

6385 PLYMOUTH AVE., ST. LOUIS 33, MISSOURI



SLEEVE BEARING MODELS AVAILABLE . . . DP Motors are built in NEMA frame sizes 182 through 445U; 1 through 125 hp—1750 RPM—40°C; available with ball bearing construction as illustrated or steel-backed, babbitt-lined sleeve bearings. Larger motors (Type RP) are available through 1000 hp.

INTEGRAL TYPE GEARMOTORS powered by Wagner DP Motors are available. These single, compact units combine Wagner motor dependability with foot mounted or flange mounted gear units to give you single, double, triple, or quadruple speed reduction.



ALL-MOTOR TYPE GEARMOTORS are also available with Wagner DP Motors. Like all Wagner Gearmotors, they have "high hardness" gears that provide greater power transmission, longer wear life, greater resistance to shock. For complete information, write for Bulletin MU-237.

WM60-20A

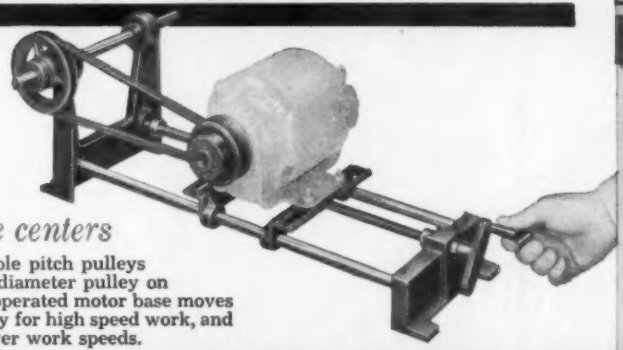
Circle No. 30 on Reader Service Card

maurey

spring loaded pulleys give you a choice of two variable speed drives

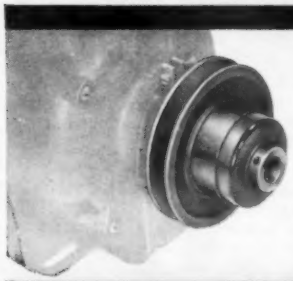
ratios up to 4:1, on 1/8 to 2 h.p. drives

1



...with variable centers

With spring-loaded, variable pitch pulleys on motor shaft, and fixed diameter pulley on driven shaft. Hand wheel operated motor base moves motor close to driven pulley for high speed work, and away from pulley for slower work speeds.

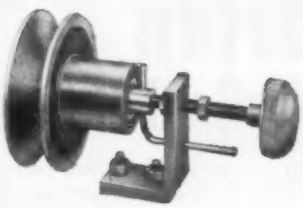


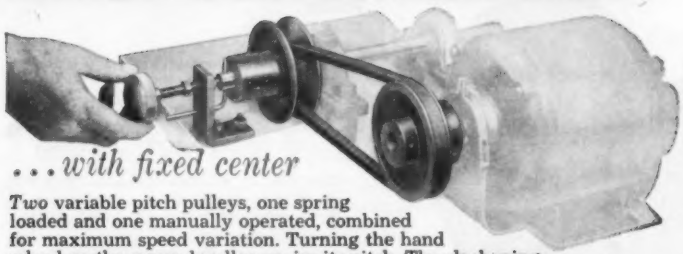
AUTOMATIC

Spring Loaded Pulley. Belt pressure controls pitch diameter. 4 sizes: 3¼", 4", 5" and 6" O.D.

MANUAL

Spring Loaded Pulley. Hand wheel controls pitch diameter. 4 sizes: 3¼", 4", 5" and 6" O.D.



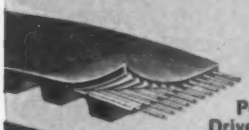


2

...with fixed center

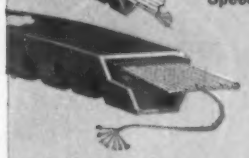
Two variable pitch pulleys, one spring loaded and one manually operated, combined for maximum speed variation. Turning the hand wheel on the manual pulley varies its pitch. The slackening or tightening belt produces instant, automatic pitch adjustment of the spring loaded driver pulley for positive driving at the desired speed.

get more **drive** *with Maurey drives*

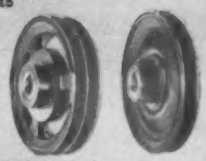


Positive Drive Belts

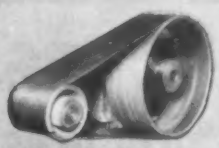
Variable Speed Belts



Mor-Grip V-Belts



Hi-Q FHP V-Pulleys



Complete heavy duty V-Belt Drives

Maureymatic Variable Speed Transmissions

Sprockets

Roller Chains

WRITE FOR CATALOGS

Here is variable speed flexibility, at truly low cost. You can use any Maurey Spring Loaded Pulley on any drive from ⅛ to 2 h.p., with any standard motor. On original equipment it involves no changes in design. On equipment in use it is installed quickly and easily. Their spring-tensioned flanges hold "A" or "B" belts in a constantly firm grip, even while you change ratios.

Get full information now,

from the Maurey Distributor listed in your local "Yellow Pages", or write direct to Maurey for catalog information.

maurey

MANUFACTURING CORPORATION

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Fast Service from these Maurey Warehouses

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POWER TRANSMISSION DESIGN

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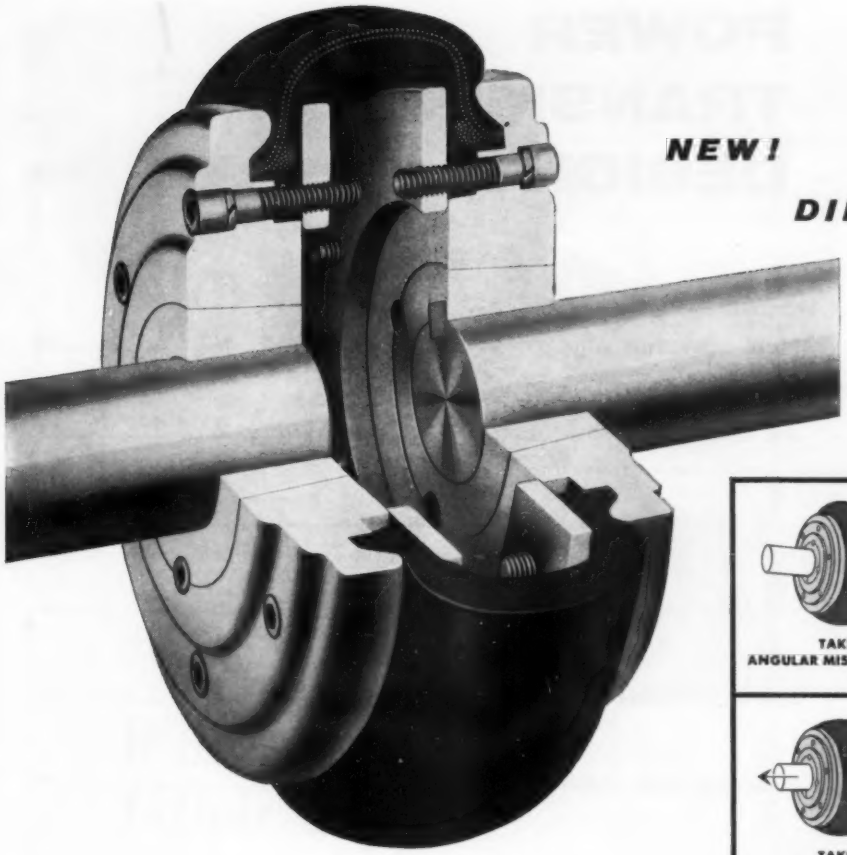
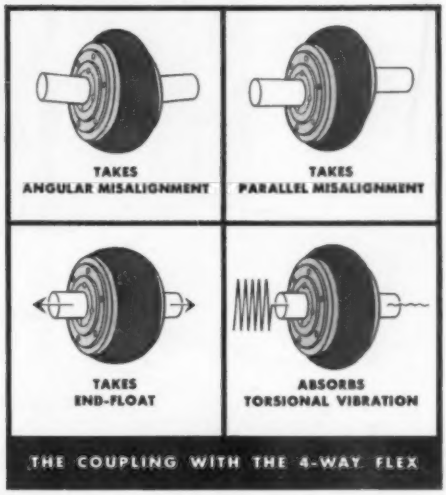


NEW!

DIFFERENT!



DODGE

Para•flex

FLEXIBLE CUSHION COUPLING

THIS coupling "swallows up" shaft misplacements. It automatically compensates for end-float, parallel misalignment, angular misalignment or *any combination of all three.* Moreover, it cushions the stresses of shock loads. And it absorbs torsional vibration—reducing noise and protecting machinery from vibration's destructive forces.

Here is a new type of performance—made possible by the development of a tire-like flexing element. Synthetic tension members, bonded together in rubber, give this element the stamina and dependability of modern, high-speed, high-load, shock-absorbing truck tires—and the ability to respond magically to all manner of changing shaft conditions.

Para-flex takes minimum space on the shaft. Mounting is simplified through the use of standard Taper-Lock bushings—no reboring, no machining. Safety is promoted by flush design; there are no protruding parts. No lubrication is required, no periodic inspection. And since the flexible member is molded with a transverse split, it can be replaced *without moving either the driver or driven machine.*

Para-flex Couplings are stocked by Dodge Distributors in popular transmission sizes. They are available from factory stock in capacities up to 2000 hp at 1080 rpm. Call your distributor for a coupling to *make your own test.* You'll witness something revolutionary!

DODGE MANUFACTURING CORPORATION, 8200 Union, Mishawaka, Ind.

DODGE
of Mishawaka, Ind.

CALL THE TRANSMISSIONEER — your local Dodge Distributor. Factory trained by Dodge, he can give you valuable help on new, cost-saving methods. Look under "Dodge Transmissioneer" in the *white* pages of your telephone directory, or in the yellow pages under "Power Transmission Machinery."

Circle No. 10 on Reader Service Card

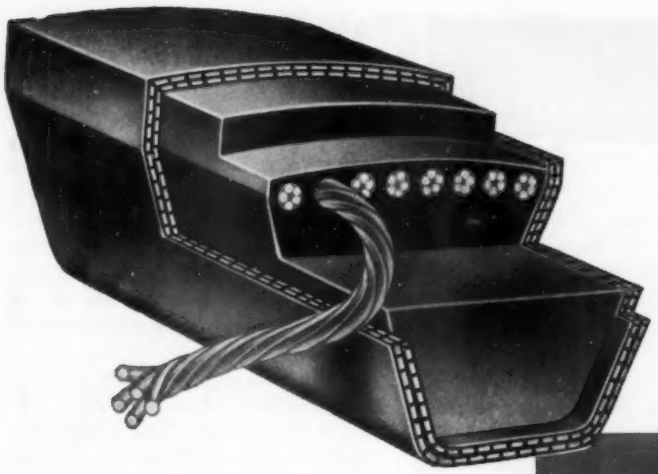
AUGUST 1960

volume 2 number 8

POWER TRANSMISSION DESIGN

FACTS AT YOUR FINGERTIPS:

Before going further, tear out a Reader Service Card which you will find bound into this issue. Fill it out as you read and mail it when you're done. We'll act on your request immediately.

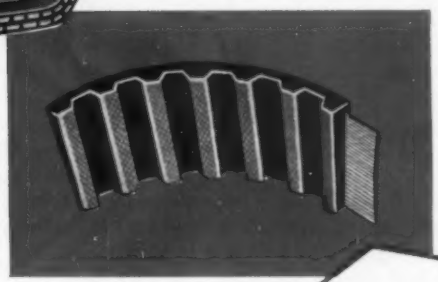


Need High Capacity In Compact Space?

DA 358 V-BELTS. This major design improvement in V-Belts brings you unprecedented compactness, high capacity and drive economy.

Chain and Gear Benefits with No Metal-to-Metal Contact?

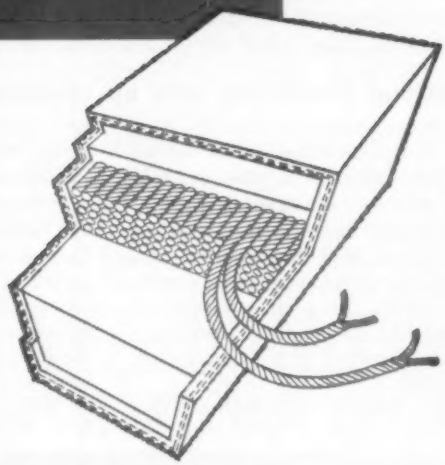
DA POSITIVE DRIVE BELTS. Revolutionary tooth-grip principle; no stretch; no constant lubrication. Highly versatile.



Whatever your V-Belt needs, DURKEE-ATWOOD *meets them*

What do you want in a V-Belt? You want consistent performance, long trouble-free life and full-rated power transmission. That means the belts must be made of the finest quality materials, with careful attention to engineering details, manufacturing processes and testing procedures. Durkee-Atwood V-Belts are made of the newest high tenacity synthetic fibres to assure length stability in storage. The exclusive Durkee-Atwood "Iso-Dynamic" Vertical Matching Machine eliminates the "sag error" that develops when V-Belts are matched on horizontal equipment. This assures equal power transmission from all belts on multiple drives . . . Look to Durkee-Atwood for *quality, service* and *savings* ...*the most complete line of industrial V-Belts.*

Look for the DA DURKEE ATWOOD SINCE 1870 *On Your V-Belts*



40% Extra Capacity in Regular V-Belts?

RED SHIELD MULTIPLE V-BELTS. Increased capacity at no increased cost. Available in oil and heat resistant and static dissipating constructions.

Top Performance in Variable Speed Drives?

VARIABLE SPEED BELTS. For constant performance. Abrasion-resistant cover; crowned cross section maintains stability under extreme loads.

DURKEE-ATWOOD V-BELTS

DURKEE-ATWOOD COMPANY MINNEAPOLIS 13, MINNESOTA

Circle No. 11 on Reader Service Card

NEWS *from the power transmission field*

Lewellen names Cottingham as distributor

DALLAS, TEX.—Lewellen Mfg. Co. has appointed Cottingham Bearings & Service Inc. to be their stocking distributor. Local stocks of variable pulleys and combination pulleys will be maintained by the Cottingham organization.

Boston Woven Hose plans new plant

BOSTON, MASS.—Boston Woven Hose & Rubber Div., American Biltrite Rubber Co., Inc., will build a plant in Hohenwald, Tenn. It will have about 200,000 square feet and cost about l3 million.

Vernitron moves offices

NEW YORK, N. Y.—Vernitron Corp has moved its executive and research and development offices to 125 Old Country Rd., Carle Place, Long Island. Transfer was caused by need for larger space one year after the company was organized. Engineering and manufacturing continue at the West Coast plant in Torrance, Calif.

Industrial Publishing sets up student award

CLEVELAND, OHIO—Lester P. Aurbach (left), president of The Industrial Publishing Corporation, publisher of POWER TRANSMISSION DESIGN, hands a $500 award to Thomas Ross, first winner of The Industrial Publishing Corporation Work/Scholarship Award. Ross, an aeronautical engineering student from Indianapolis, was president of his junior class at Purdue.

The annual award, established this year, points up career opportunities in the business press to young men with technical educations. It is open to juniors at six engineering colleges: M.I.T., Rensselaer, Ohio State, Case, Purdue, and Carnegie Tech. Winners —judged on scholastic average plus interest and aptitude evidenced by examinations and interviews—get the cash award and ten weeks' summer employment on an Industrial Publishing Corporation magazine.

Atomic generators for automobiles?

DETROIT, MICH.—For the first time, direct conversion of the energy of high speed molecular fragments into electricity or other forms of power has been demonstrated in experiments made by the newly-formed Energy Conversion Laboratories. Constant streams of highly reactive particles known as free radicals can be produced in a safe and self-sustaining system.

Until now study of free radicals was possible only at very low cryogenic temperatures. This system controls the natural atomic reaction at near room temperatures.

According to Stanford R. Ovshinsky, inventor-founder of E. C. L., analysis of data from working models suggests the possibility of packaged power units that will operate continuously without moving parts and completely independent of conventional power sources. Typical uses would be generators for remote areas and small power plants for vehicles—including automobiles.

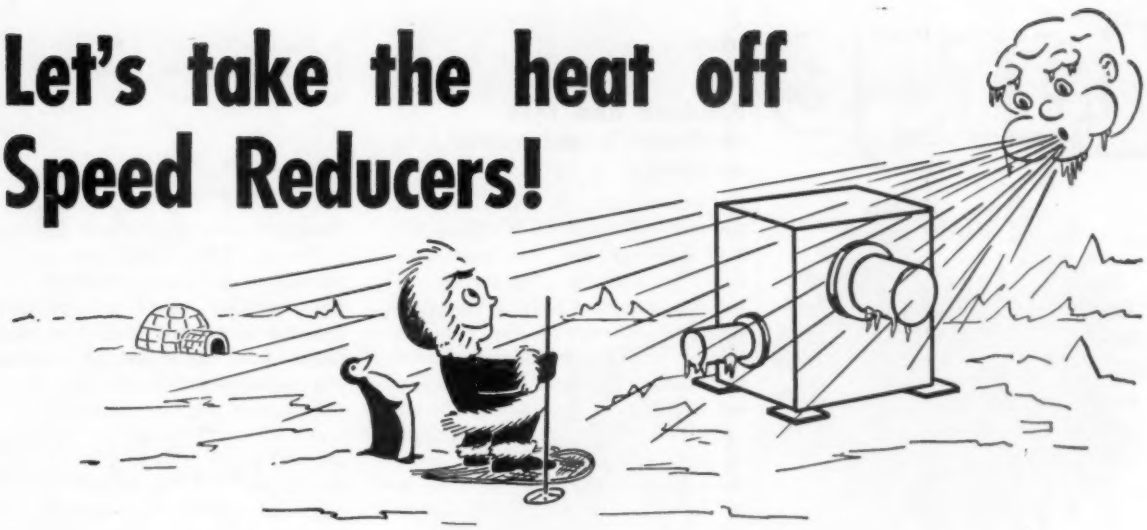
Manheim begins 50th year

MANHEIM, PA.—An "open house" for employees and families on June 4 marked the beginning of Manheim Mfg. & Belting Co.'s 50th year. About 200 guests attended and were taken on plant tours and served dinner. The company was established on May 16, 1911. Its first product was Veelos balata belting which is still manufactures among many other products.

Massive chain drives exhibited

CHICAGO, ILL.—What are said to be the world's largest chain drives were shown in operation as part of Morse Chain Co.'s Pageant of Progress exhibit in the Borg-Warner Museum of Science and Industry. Made of aluminum, one drive measured 16 in. wide by 38½ ft. long; the other, a replica of the Morse Chain Hy-Vo drive was 12 in. wide by 28½ ft. long. Production models of the latter work successfully at speeds up to 13.250 ft. per minute.

Let's take the heat off Speed Reducers!



A worm gear speed reducer is one of the toughest little customers in captivity. It reduces speeds day-in, day-out, with little complaint. While it works long and hard, it has limitations—set by ratio, center distance, RPM, mechanical and thermal HP ratings, etc. And, depending upon how precisely it was selected and fitted to the job requirements, it will do what it has to do.

But sometimes it's forced to play outside of its league. It must cope with job requirements that vary from here to there—normal 8 to 10 hour service without recurrent shock, the same length of service where there is some shock loading, continuous low-speed service and almost countless others. But the thing that really puts the pressure on reducers, the thing that's lurking in *every* set of job requirements—is h-e-a-t.

When you exceed the thermal capacity of a reducer for more than an hour or so, excessive temperature thins the lubricant resulting in wear; material, bearing and oil seal failures; etc. Of course, the proper lubricant will help but it can't cure the continuing problem of excessive heat.

So how can we lick this toughy? One way is to build the reducer housing oversize, big enough to radiate the heat away and keep temperatures down. But this type sticks out in aisles, louses up compact designs and barks shins. Then, we might try a smaller housing complete with fins on it to dissipate the heat. If this still doesn't work, another trick is to use a reducer with capacities and ratings a step above the ones we need. This is sending a man to do a boy's job. It's impractical, inefficient and costly. There *has* to be an easier, better, saner and cheaper way to do it. And there is!

In certain cases, where the size and type of reducer permits and where we can gain enough in thermal HP rating to keep heat generation in bounds, Cone-Drive Gears does it with fan-cooling.

What's that? Simple. Just add a fan to the worm shaft plus the necessary air shields, fan cover, etc., and presto!—heat is no longer a problem. The air shields direct the fan-pushed air over the fins on the lower portion of the reducer. The fins are shaped and spotted to guide the air stream where it is needed. Thermal HP ratings are boosted tremendously, as high as 147% above those of standard reducers in some cases! Those over-worked, over-heated reducers will now do the job you bought them to do.

Other advantages? They're here in abundance. The size of the reducer stays the same. All parts on a Cone-Drive fan-cooled reducer are 100% interchangeable with parts for standard reducers. Oil capacity is identical. Shields are quickly removed without disconnecting the reducer. (This is important where severe operating conditions make periodic cleaning necessary). The reducer can also be operated *without* fan-cooling just by taking off the fan and shields.

This simple addition to standard Cone-Drive HU speed reducers might be just your answer—might save you some money. Write for Cone-Drive's Bulletin CD-218. It will tell you all about the full line of Cone-Drive double-enveloping worm gear reducers as well as the fan-cooled kind. Cone-Drive Gears, Div. Michigan Tool Co., 7171 E. McNichols Rd., Detroit 12, Mich.

Circle No. 7 on Reader Service Card

Produce and test customer's instrument bearings

PETERBOROUGH, N. H.—The Rot-assembly Div. of New Hampshire Ball Bearings, Inc., has been established as a facility for making and testing instrument bearing assemblies designed entirely by the customer. Service available includes evaluation and costing of designs by experienced engineers at no charge. Manufacture takes place in a specially equipped section. Test and assembly equipment used is the same as that for producing bearings to ABEC 7 tolerances and better. Send inquiries to either regional offices in Hollywood, Des Plaines and Great Neck, or the main plant in Peterborough, N. H.

Airborne Accessories expands

LOS ANGELES, CALIF.—West Coast Div. of Airborne Accessories Corp. will be located at larger premises at 5456 W. Washington Blvd. from June 6. The new facility will be directed by Edward W. Vernon, West Coast Div. manager.

Fuel cells for electric trucks

PHILADELPHIA, PA.—Exide Industrial Div. of The Electric Storage Battery Co., in combination with 12 leading material handling equipment manufacturers, will develop an adaptation of the Exide fuel cell to power electric industrial trucks.

Fuel cells are essentially advanced types of storage batteries but capable of power efficiencies at least double the 40% maximum of conventional motors and generators. The Exide cell, using zinc as fuel and compressed oxygen as oxidizer, produces no waste products and operates at nearly normal temperatures and pressures. It can be scaled up or down in size and electrical capacity.

Already advanced beyond the applied research stage, the design is said to be suitable to mass production and may eventually be used in street cars, trucks, buses, etc. after further industrial testing.

Gas turbine powers fire trucks

SEATTLE, WASH.—Two fire trucks built by the American LaFrance Corp. will be powered by a 325 hp gas turbine made by the Boeing Industrial Products Div. They have been ordered by the cities of San Francisco and Seattle, and are said to be the first of their kind.

The Seattle truck is a 100-foot aerial ladder that weighs 32,500 lbs. San Francsico will receive a 1000 gallon-per minute pumper weighing 20,000 lbs. Formerly, these types of fire trucks were powered by reciprocating engines weighing up to 3,500 lbs. The Boeing 502 turbine weighs 325 lbs or about one per cent of the total truck weight.

The turbine has high torque performance at low speeds, which will enable the trucks to accelerate from zero to 55 mph in 34 seconds. It needs no warm up time and uses a conventional transmission. Low maintenance and simplicity of design for easy take-down are other advantages. Delivery of the trucks is expected in the fall.

New computer lab at National Broach

DETROIT, MICH.—National Broach & Machine Co. has installed a new computer laboratory in its engineering department to carry out the mass of computations needed in gear tool design. Electronic digital computer equipment will be used in designing gear shaving cutters, gear honing tools, master gears, and broaching tools. It will also be used for analytical work on the design of gears and splines and related tooth shapes.

Opens west coast gear motor center

SCHENECTADY N. Y.—General Electric's Gear Motor and Transmission Components Dept. has opened a new gear motor center in San Francisco. Western customers can now call in specialized assistance to apply, modify and repair power transmission products. The new center, located at 1098 Harrison St., will carry a large stock of parts as well as fractional type gear motors.

MEETINGS

SEPTEMBER

6-16 Production Engineering Show, Navy Pier, Chicago.

6-16 Machine Tool Exposition, International Amphitheatre, Chicago.

14-16 National Petroleum Association, Annual Meeting, Hotel Traymore, Atlantic City, N. J.

15-16 American Institute of Mining, Metallurgical, and Petroleum Engineers, Engineering Management Conference, Joint Committee, Morrison Hotel, Chicago, Ill.

OCTOBER

17-19 American Society of Mechanical Engineers-American Society of Lubrication Engineers, Lubrication Conference, Statler Hilton Hotel, Boston, Mass.

30-Nov. 1 National Lubricating Grease Institute, Annual Meeting, Edgewater Beach Hotel, Chicago, Ill.

3-4 Society of Automotive Engineers, National Fuels and Lubricants Meeting, The Mayo, Tulsa, Okla.

27-Dec. 2 American Society of Mechanical Engineers, Annual Meeting, Statler-Hilton Hotel, New York.

MEN of the power transmission field

Twin Disc elects Schuman

RACINE, WIS.—G. L. Schuman has been elected to the Board of Twin Disc Clutch Co., Racine, Wis. He is

SCHUMAN

vice president in charge of finance and secretary of the firm which manufactures a wide line of industrial friction and fluid drives. Schuman has been with the Twin Disc organization since 1928 and was elected to the vice presidency in 1951.

Fort Worth Steel appoints Burke

FORT WORTH, TEX.—John Burke has been appointed St. Louis district manager of Fort Worth Steel & Machinery Co. Previously customer service engineer in the firm's Fort Worth headquarters, he will now work from the St. Louis warehouse and office.

Eaton Mfg. names Moretti, Daisley

CLEVELAND, OHIO—Thomas A. Moretti has been appointed special assistant in the industrial relations department in an expansion of Eaton's industrial relations staff. In 30 years of service, Moretti has held a number of important positions in production, personnel and industrial relations. His last job was plant manager of Eaton's former Marion Forge Div.

Malcolm Daisley, Eaton's wage and salary administrator from 1957, was promoted to general employe relations manager, a new post. A graduate of Wesleyan University, Middletown, Conn., and the University of Chicago, Daisley joined Eaton in 1954 as assistant industrial relations manager in the Battle Creek Valve Div. and became industrial relations manager in 1956.

Dayton appoints Falsken, Webb

MELROSE PARK, ILL.—Donald E. Falsken has been appointed sales manager of the Automotive Wholesale Dept. of Dayton Industrial Products Co. Falsken, formerly western region sales manager, succeeds R. G. Roney who has resigned. He'll handle

FALSKEN

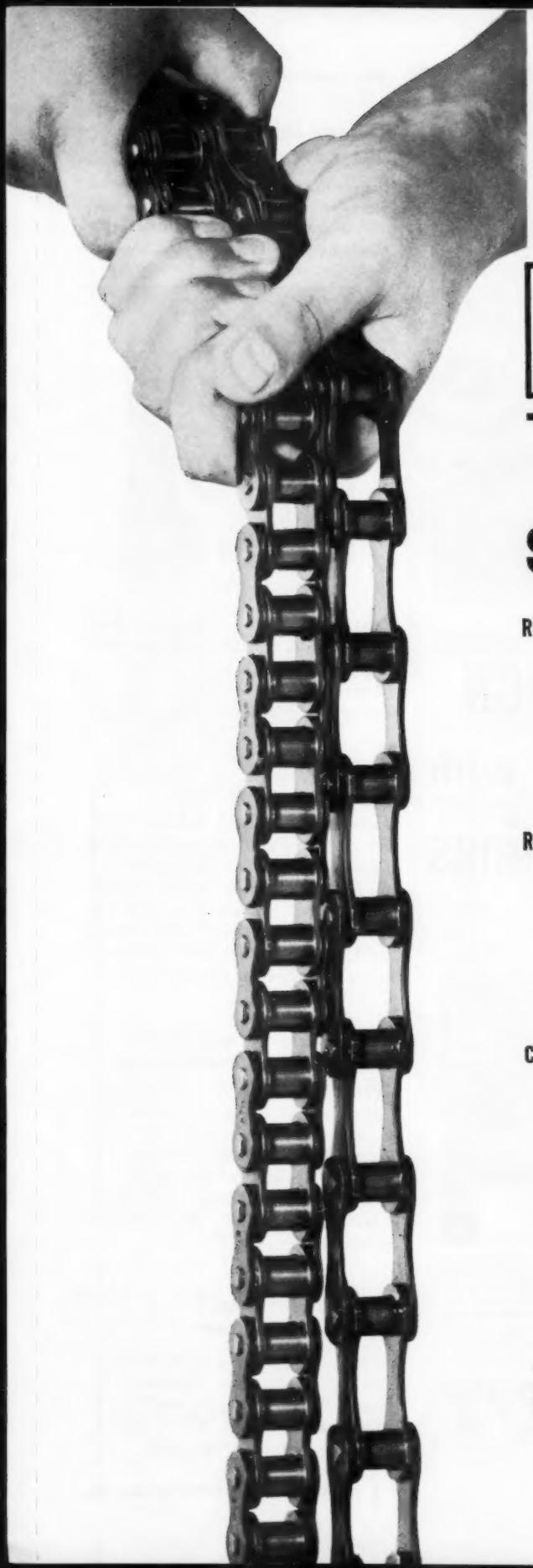
WEBB

sales of Dayton's line of automotive products which includes V-belts, radiator and heater hose, and tandem V-belt drives for the replacement market.

At the same time, K. D. Webb becomes assistant sales manager. He was formerly southeastern regional sales manager for the department.

Daystrom assigns Stulpin to new product group

NEWARK, N. J.—Edward J. Stulpin has been named product manager of a new Transducer Product Group of the Weston Instruments Div. of Daystrom, Inc. He'll handle sales of tachometer generators, photocells, thermal convectors, copper oxide rectifiers and thermoelements. Stulpin, a graduate of Rutgers University, joined Daystrom in 1954.



This Chain Contains ALL the Oil it will EVER Need!

IT'S WHITNEY MSL* SELF-LUBRICATING CHAIN

RUNS CLEAN BECAUSE IT'S SELF-LUBRICATING

Whitney MSL* Power Transmission and Conveyor Chain is lubricated for life by oil-impregnated sintered steel bushings. In operation, the lubricant expands and flows over all vital bearing surfaces; when the drive stops, the lubricant contracts and is reabsorbed by the bushing. This cycle continues throughout the chain's service life. *No additional oil is required.* This means clean running chain—no contamination of product or materials in food, textile, paper, chemical and packaging industries!

RUNS LONGER BECAUSE IT'S SELF-LUBRICATING

MSL* Chain outlasts conventional pre-lubricated chain as much as 5 to 1 in severe operating requirements. Built-in lubrication at the 3 critical wear points—Pin, Plates, and Sprocket Engagement—solves a major chain problem: more damage is caused by faulty lubrication than by years of normal service. Highest material standards, advanced manufacturing processes and self-lubrication are combined in MSL* Chain to give you longer service life.

COSTS LESS TO USE BECAUSE IT'S SELF-LUBRICATING

By eliminating the need for manual lubrication or lubricating devices, Whitney MSL* Self-Lubricating Chain ensures *lower installation, maintenance, and use cost.* Whitney MSL* Chain conforms to A.S.A. Standards and is completely interchangeable with any similar pitch chain.

Get complete details on this outstanding chain today. Ask your nearby Whitney Chain Distributor, or write for Bulletin MSL B-2.

***Maximum Service Life**

THE WHITNEY CHAIN COMPANY
a subsidiary of FOOTE BROS. GEAR AND MACHINE CORPORATION
4575 S. Western Blvd., Chicago 9, Ill.

POWER TRANSMISSION DRIVES
Circle No. 33 on Reader Service Card

Rodney-Davis fills new post

PHILADELPHIA, PA.—Stephen Mucha has been named for the new position of sales manager of Rodney-Davis Gear Co. He'll be responsible for

MUCHA

sales, marketing and sales promotion. Mucha, a mechanical engineering graduate of Swarthmore College, formerly was in charge of sales at Foster Equipment Co., Philadelphia, Pa.

Changes at Timken

CANTON, OHIO—H. J. Urbach, formerly company executive engineer, has been named director of engineering in Timken's Engineering Div. Ralph E. McKelvey, whose previous job was assistant chief engineer of the Physical Laboratories has been promoted to assistant director of engineering.

Schwanitz is assistant treasurer at Formsprag

WARREN, MICH.—V. J. Schwanitz, former senior accountant in the Detroit auditing staff of Ernst & Ernst, has been made controller and assistant treasurer of Formsprag Co. Schwanitz is a graduate of the Business Institute, Detroit, and a certified public accountant.

Norma-Hoffman promotes Wilson

STAMFORD, CONN.—Norma-Hoffman Bearings Corp. has appointed G. Bruce Wilson assistant eastern regional sales manager. Wilson formerly was Detroit district manager.

Hoppenstedt joins Hewitt-Robbins

STAMFORD, CONN.—E. Allen Hoppenstedt takes over as sales manager of the International Div. of Hewitt-Robins, Inc. He'll be responsible for export sales as well as sales of affiliated companies in other countries. Hoppenstedt formerly managed the International Div. of the Fischer and Porter Co., Hatboro, Pa.

Daniels adds Gerlach to sales force

DANIELS, MD.—Jack R. Gerlach has joined the Belting Sales Dept. of C. R. Daniels Inc. as sales manager

GERLACH

for the Ohio and western Pennsylvania and western New York State areas. He was previously sales manager for Cleveland Punch and Shear Co. and did special assignment engineering sales with P. R. Mallory and Co., Inc.

Ogilvie joins Merkle-Korff

CHICAGO, ILL.—Ira B. Ogilvie has joined the Merkle-Korff Gear Co. as advertising manager. He was previously with the George Gorton Machine Co. for more than fifteen years as advertising manager and is a past national director of the Association of Industrial Advertisers.

Kendall joins Wellman

BEDFORD, OHIO—Fred E. Kendall, former vice president and director of research for the Lectroetch Co., has joined The S. K. Wellman Co. as assistant to the president. He'll have special assignments for manufacturing and plant operations.

Would you spend an extra 10%

to double roller chain life?

Morse H-E Roller Chain overcomes metal fatigue . . .

lasts from 2 to 5 times longer . . .

costs only 10 per cent more than ordinary roller chain!

Yes, now by paying just a slight premium you can buy Morse H-E (high endurance) roller chain . . . and get 2 to 5 times the service life over ordinary chain. Here's why:

Normal roller chain breaks sooner under the rigors of "stop-and-start" or heavy strain operations. It's this "tired metal" problem that plagues anyone who has used roller chain. Morse has developed a process to overcome metal fatigue. As a result, Morse H-E Roller Chain has a 95% greater endurance limit . . . lasts up to 500% longer . . . costs just 10% more.

Make a test yourself. Next time you need roller chain, try Morse H-E and compare. Your Morse Chain distributor is the man to see. He's listed in the Yellow Pages under "Power Transmission." Or write: Morse Chain Company, Dept. 27-80, Ithaca, N.Y. Export Sales: Borg-Warner International, Chicago 3, Ill. In Canada: Morse Chain of Canada, Ltd., Simcoe, Ont.

ORDINARY CHAIN BREAKS when the side plate tires from repetitive loading and unloading during the cycle around the sprockets. But Morse H-E Roller Chain has a 95% higher endurance limit . . . outlasts ordinary chain by up to 5 to 1 under repeated loading.

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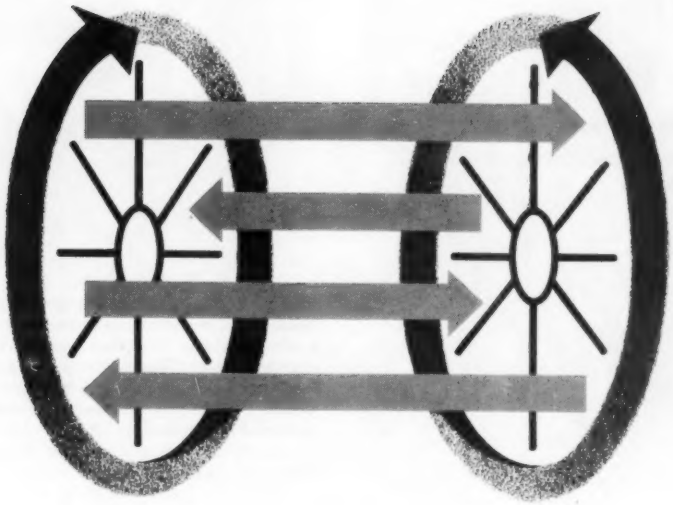


Fluid couplings and torque converters

- *How they work*
- *Characteristics*
- *Sizes*
- *Selection*
- *Application*

THERE ARE two general types of devices which use a fluid, generally oil, as the power transmitting medium. They are hydrostatic and hydrodynamic drives. Hydrostatic drives use positive-displacement hydraulic pumps and motors. Hydrodynamic drives are the fluid couplings and torque converters to be discussed in this article. The term hydrodynamic is used because power transfer in this type of drive is through the kinetic energy of the fluid in motion. In hydrostatic types, static pressure of the fluid is the primary means of power transfer.

How They Work

In both fluid couplings and torque converters, Figure 1, the input shaft drives a centrifugal pump or impeller. The pump delivers fluid to a turbine which is sometimes called a runner. The impeller and turbine are positioned very close to each other with little more than running clearance between them. The units are shaped so that oil leaving the pump passes directly

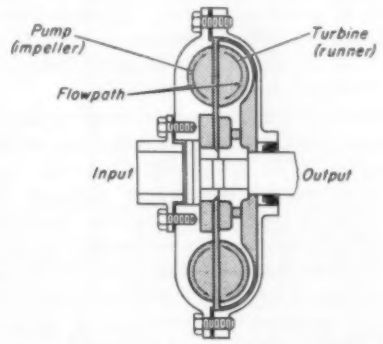
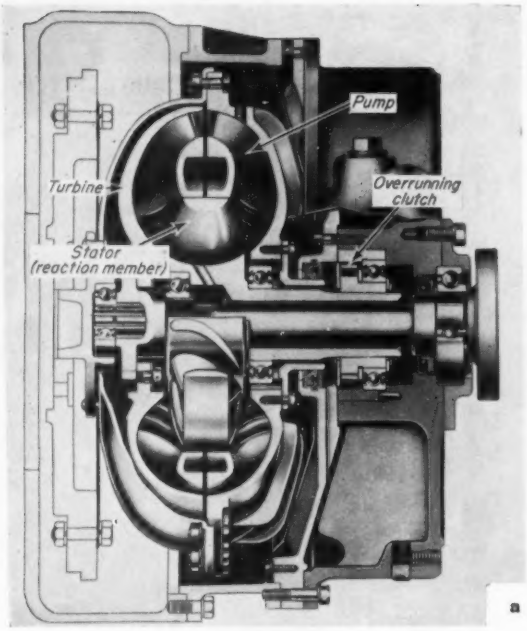


Fig. 1. Power is transmitted by a fluid, usually oil, in torque converters and fluid couplings. A centrifugal pump, sometimes called the impeller, increases velocity of the fluid. The turbine, or runner, slows the fluid down, and extracts kinetic energy which drives it. Because power transmission is through this change in kinetic energy, these devices are called hydrodynamic drives. This is a fluid coupling.



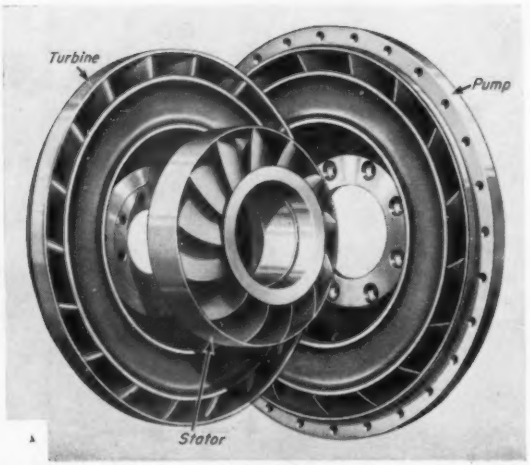


Fig. 2. Addition of a reaction member, or stator, to a fluid coupling changes it to a torque converter. This is a single-stage, two-phase converter. The overrunning clutch allows the reaction member to turn when relative speeds of pump and turbine approach each other. When this happens, the converter is in the coupling phase of operation.

FLUID COUPLINGS *continued*

to the turbine, and oil leaving the turbine passes right to the pump.

Since oil leaving the impeller is accelerated to a higher velocity than that at which it entered by centrifugal force, its kinetic energy is increased. As it travels through the turbine, it gives up a portion of this energy to the turbine and slows down. This change in kinetic energy is the power delivered to the turbine.

Because both impeller and turbine are identical as far as fluid flow path is concerned, each can function as a centrifugal pump. Therefore, there must be a difference in speed between the two or there would be no difference in pressure to create the circulation from pump to turbine. This difference, or slip, is usually from 3 to 5% minimum for a properly matched prime mover, drive, and load.

The difference between a fluid coupling and torque converter is that the torque converter has at least one more member in the circulating oil circuit, Figure 2. The addition of this member or members lets the torque converter multiply torque. The fluid coupling cannot mutiply torque. Torque multiplication in the torque converter results because the added member changes direction of the oil flowing from turbine to impeller and increases the momentum of the oil by this direction change. Performance characteristics of coupling and converter are compared in Figure 3.

By using an overrunning clutch to mount the reaction member, or members, of a torque converter, the characteristics can be modified as shown by the dotted curve in Figure 3. This modification lets the converter function as a fluid coupling during portions of the operating cycle. The converter, thus, has two separate phases of operation—converter phase and coupling phase. Converters of this type are labelled two-phase. There are also polyphase converters with additional elements.

Converter curves, Figure 3, are for a 2-phase type where the reaction member freewheels at speed ratios above .72 to let the converter function as a fluid coupling. As the curves show, this improves efficiency of the converter, but efficiency is still not quite as high as that of the fluid coupling. Torque curves are for constant-speed prime mover.

Performance Analysis

Torque capacity of a fluid coupling, that is the torque needed to drive the impeller, is given by

$$T = cn^2D^5 \quad \text{.....(1)}$$

where T = torque, lb-ft
n = impeller speed, rpm
D = diameter of the body of liquid in the coupling, ft
c = a coefficient (varies with fluid coupling design)

This shows that torque varies as the square of impeller speed and as the fifth power of the diameter of the liquid in the coupling.

Input power is found by substituting Equation 1 in the standard horsepower equation to obtain

$$hp = \frac{2\pi cn^3D^5}{33{,}000} \quad \text{.....(2)}$$

This shows that power capacity is proportional to the cube of impeller speed and the fifth power of the liquid diameter.

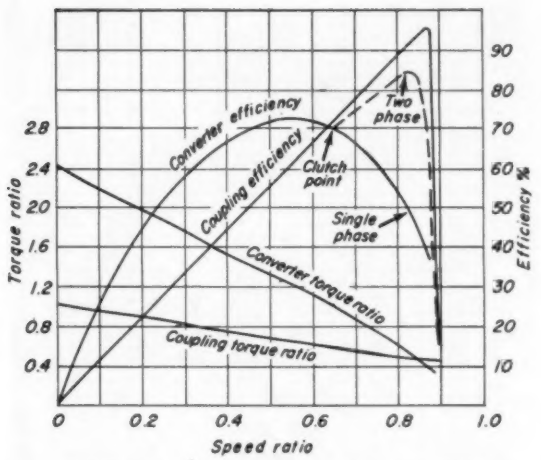


Fig. 3. Efficiencies and torque ratios of a fluid coupling and single stage torque converter vs. speed ratio. In addition to offering torque multiplication, the converter is more efficient up to a speed ratio of about 0.7. Efficiency of the single-phase converter falls off very rapidly from this point if the reaction member is fixed. By mounting the reaction member on an overrunning clutch, converter efficiency approaches that of the fluid coupling from the clutch point on. Clutch point is where the reaction member starts to freewheel.

Torque given by Equation 1 is called *Stall Torque*. This is the impeller torque when the turbine speed is zero. For a fluid coupling, this is the maximum torque load seen by the prime mover and also the maximum output torque. Relative speeds of pump and turbine also effect torque. When they are equal, no torque is transmitted. However, for points between stall and speed ratio of 1.0 (pump speed = turbine speed) there is no simple mathematical relationship. Some typical torque-slip curves are shown in Figure 4. In drawing these curves, a constant input speed, n_i, is assumed. Under these conditions, torque and slip are very nearly proportional over the zero to 10% slip range.

Performance of torque converters is not quite as easy to analyze as coupling performance. Primary reason for this is the number of different types of converters, Fig. 5. Torque-slip curves for converters, Fig. 6, when compared to the curves for fluid couplings, Fig. 4, show that torque absorption of the converters is more nearly constant over the slip range. It's important to remember that input torque is the maximum load the converter presents to the prime mover at various output speeds when input speed is held constant.

Advantages

All hydrodynamic drives protect the prime mover and other drive train components from shock loading. They offer protection against torsional vibration, also.

Low maintenance requirements and long life are inherent feaures of hydrodynamic drives. The number

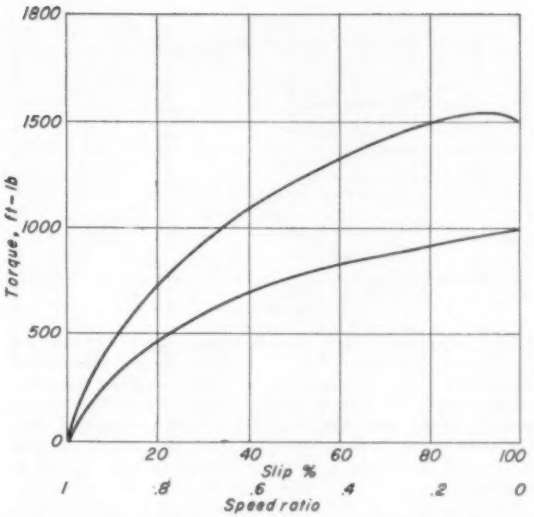


Fig. 4. Torque vs. slip curves for two acual fluid couplings. These demonstrate that slip and torque are nearly proportional (straight lines) between zero and 10% slip.

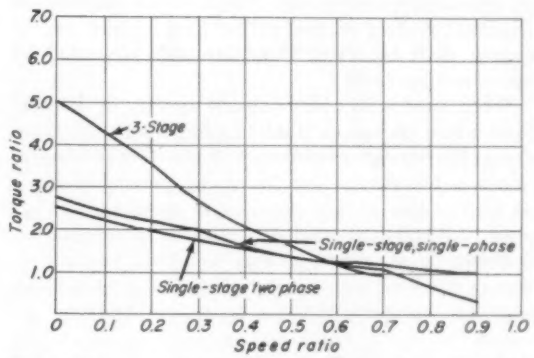


Fig. 5. Torque ratio vs. speed ratio for three different torque converters. When selecting a torque converter, its characteristic and prime mover characteristic should be matched as closely as possible with load requirement.

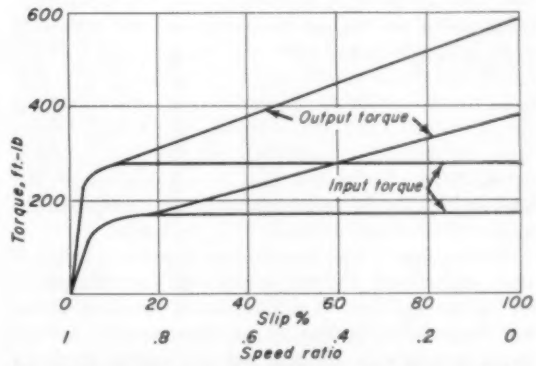


Fig. 6. Input and output torque vs. slip for two similar torque converters. The converters are single-stage, two-phase types. Note how nearly constant the input or torque absorption curves are. This is the limit of the load applied to the prime mover.

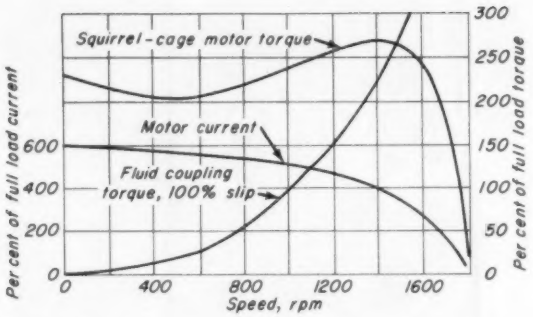


Fig. 7. Squirrel cage motor torque and current vs. speed and the curve of fluid coupling torque absorption show that torque demand of the fluid coupling does not reach 100% of rated motor torque until the motor reaches 1000 rpm. And, this is for 100% coupling slip. In most cases, torque demand and, therefore, current draw will be even less until higher motor speed is reached.

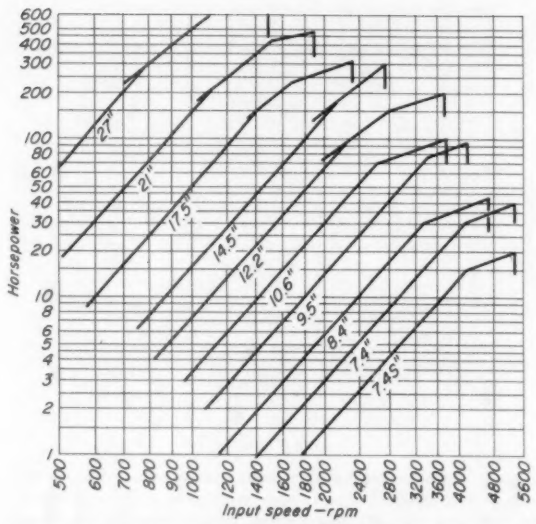


Fig. 8. Charts like this supplied by manufacturers simplify fluid coupling selection. Data may also be supplied in the form shown in Table I. Speed, horsepower, and coupling size are related by the chart.

FLUID COUPLINGS *continued*

of operating parts is few. There is no rubbing or frictional contact of any of the parts. There are, of course, shaft bearings. These are well lubricated by the operating fluid.

When used with either electric motors or internal combustion engines, a fluid coupling applies the load gradually during acceleration. Since torque absorption is a function of impeller speed squared, there is no load on the prime mover at zero speed and the applied load builds up gradually as speed increases. This is shown by the curves in Fig. 4. With a torque converter, the load seen by the prime mover would be even less, assuming that the loads are identical.

Selection

Nature of the load and the prime mover are the important considerations when making a decision on whether to use a fluid coupling or torque converter. The fluid coupling is generally at its best in applications where the highest percentage of the operating cycle is at a high and relatively constant speed. Other conditions which should exist in combination with this to justify use of the fluid coupling are: shock loading, frequent starts and stops, or the starting of high-inertia loads. In starting high-inertia loads, the fluid coupling automatically limits the rate of application of the load and allows the prime mover to come very quickly up to speeds where it can handle the loads.

The last-mentioned feature is particularly valuable when an internal combustion engine is the prime mover. Internal combustion engines must operate at speeds well above idling to develop maximum torque. A fluid coupling, properly selected, lets the engine reach its maximum torque speed with no strain.

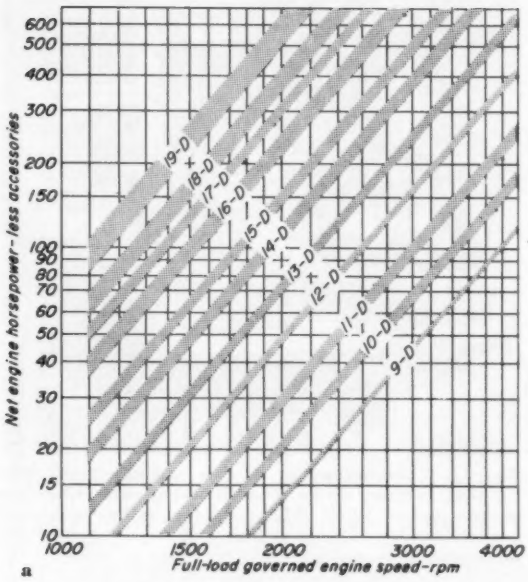
A fluid coupling will limit the starting current draw of a squirrel cage or other electric motor which requires less current to produce torque equal to or higher than its starting torque when at higher operating speed, see Fig. 7.

Torque converters, because of their higher efficiency over a wider speed range, and their ability to multiply torque, offer all the advantages of the fluid coupling, plus. Probably the best example of an application ideally suited to a torque converter drive, is an internal combustion engine powered vehicle. Here, very high torque is needed to start the vehicle from a standstill. The engine can't provide high torque at low or idle speed. But, the engine-converter combination provides output speed vs. torque characteristics that are a very good match for the requirements. Other aspects of vehicle operation which are well handled by a torque converter are the changes in torque requirement with

Table I—Fluid Coupling Selection Data

hp	Size no.	Output rpm*	Stall torque (% full load)*
1/2	55	1580	220
3/4	55	1525	212
1	55	1600	230
1	76	1690	270
1 1/2	76	1660	240
2	76	1655	209
3	76	1620	215
5	92	1640	206
7 1/2	92	1660	211
10	107	1640	190
15	107	1660	188
20	107	1640	196

*Based on typical motor performance and full-load rpm of 1750.



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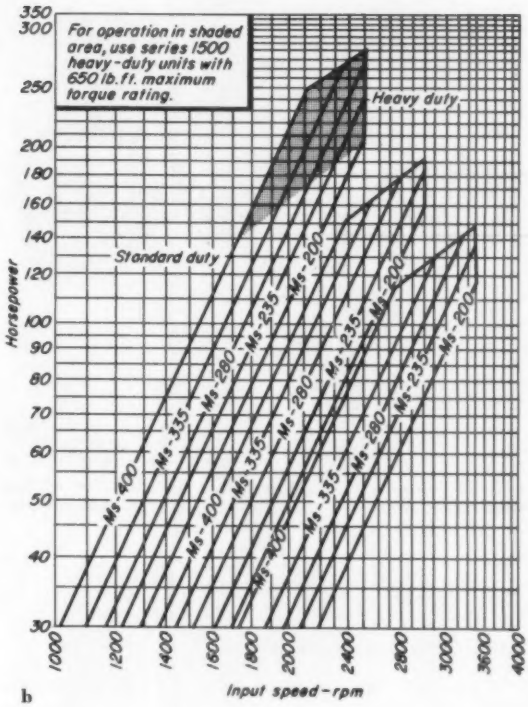


b

Fig. 9. Torque converter selection charts.

changing weight of loads carried, and changing grades. When used with an internal combustion engine, a torque converter may be thought of as a continuously variable ratio transmission which automatically adjusts to just the right ratio for any condition if it's within the 6 or 7:1 maximum range available.

Size matching: Selecting the right size fluid coupling is relatively simple. To keep efficiency high, the coupling should have 3 to 5% slip at full load and normal operating speed. With a squirrel cage or induction motor, this limits peak torque that can be applied under any condition to 2 or 3 times full-load torque.

Data published by fluid coupling manufacturers to aid in selection may be either tables or curves showing horsepower transmitting capability for a given input speed, Fig. 8, Table I. When your job falls about halfway between the figures for two standard units, remember this: It's usually very easy and costs little or nothing to adjust the performance of the larger of the two units to exactly fit the job. One way of doing this is by varying the amount of oil in the coupling. The 12 ratings given in Table I are gotten from 4 fluid couplings in this way.

Size matching for converters is no more complicated than for fluid couplings. Manufacturers provide speed-hp curves to let you pick one out, Fig. 9. However, before this step careful consideration must be given to properly matching duty cycle, and prime mover with the correct type of converter.

Type matching: As previously mentioned, there are single and multi-stage torque converters as well as single and two-phase units. Each of these has certain speed-torque characteristics which must be compared with job requirements when selecting a converter.

Sizes, Styles and Ratings

Both fluid couplings and torque converters are available for operation with input and output speeds to about 4000 rpm, as standard off-the-shelf items. These figures are, of course, consistent with the normal operating speeds of electric motors and internal combustion engines. Maximum permissible speeds decrease as the size and diameter of the units increases. Manufacturers' speed ratings are based on two factors. One is the actual physical strength of the unit needed to resist centrifugal force. The other is heat dissipating ability of the unit. When operated at speeds higher than recommended, losses may exceed the heat dissipating capacity of the unit even though efficiency remains high.

Horsepower ratings range from ½ hp to 12000 hp. There are few to choose from at this high power rating. Quite a few manufacturers have units for up to 500 hp. Torque ratings are as high as 17,500 lb-ft. Again, this value is an exception.

Charging: Torque converters and fluid couplings may be filled, or charged, with fluid and sealed. When this is done, a virtually maintenance-free unit is obtained. Disadvantages of this charging method are: (1) space for expansion of the fluid due to heating must be allowed which means that 100% of unit capacity is not available due to reduction in oil charge (this reduction is extremely small); (2) all heat generated in the unit must be dissipated by the housing. This can be a real drawback, particularly on torque converters which have somewhat lower efficiencies than fluid couplings.

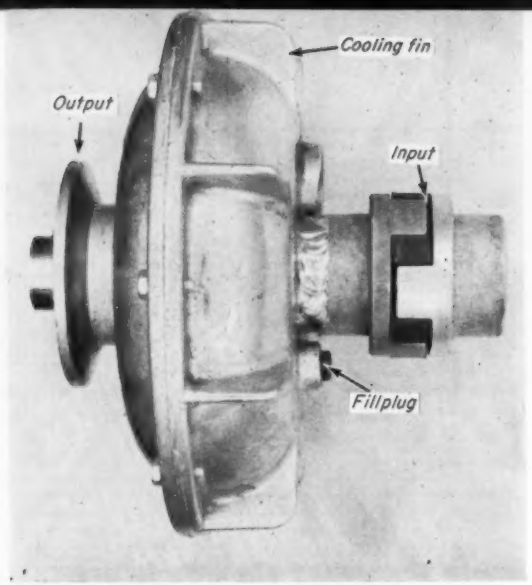


Fig. 10. This fluid coupling has a fill plug for adding fluid. The plug is located far enough in from the OD of the unit so it cannot be overfilled.

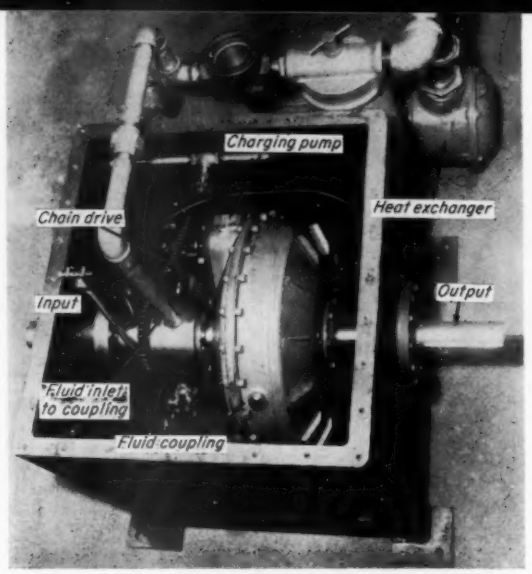


Fig. 11. Charging pump of this variable-speed fluid coupling is chain driven from the input shaft. Charging pumps permit 100% filling fluid coupling or torque converter. They also let a heat exchanger be used for additional fluid cooling.

FLUID COUPLINGS *continued*

Some units are provided with fill plugs. Comments on sealed units also apply to these. It's possible to reduce the charge and thus modify the characteristics of these units. When doing this it's extremely important that the manufacturer's instructions be followed to avoid overfilling and possible damage because the necessary expansion space is not allowed. As a safety precaution, the plug is usually positioned so it's impossible to completely fill the unit, Figure 10.

A much used charging method is with a pump to constantly circulate the working fluid through the coupling or converter, Figure 11. This allows 100% filling and additional cooling in a sump, external oil lines, or a heat exchanger. The charging pump also introduces a means of control. Since the fluid is forced into the unit by the pump but forced out by centrifugal force, it's possible to completely or partially drain the fluid during operation to modify the characteristics or completely disconnect the coupling or converter. This total disconnect feature can be valuable when starting an engine and during periods when a vehicle is stopped because it minimizes or eliminates creep when the vehicle is supposed to be standing still.

There are fluid couplings designed to be used as adjustable-speed transmissions by varying the degree of fill, Figure 12. In these units, a scoop tube is mechanically positioned to withdraw fluid to a particular level. Either manual or powered positioning of the scoop tube can be used. Efficiency of variable-fill fluid couplings is equal to the output to input speed ratio. Therefore, when output shaft speed is reduced to one-half input shaft speed, efficiency is 50% and half the input horsepower is converted to heat in the coupling. A heat exchanger for fluid cooling must always be used with one of these units.

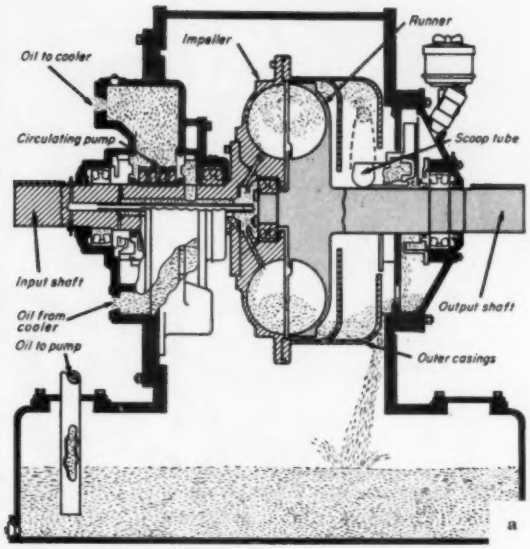
Mountings: Fluid couplings and torque converters are available for mounting directly on electric motor shafts. Fluid couplings are available with concentric input and output shafts and incorporate a V-belt sheave, Fig. 13. This lets them be mounted directly on the motor shaft with no other support or mounting needed.

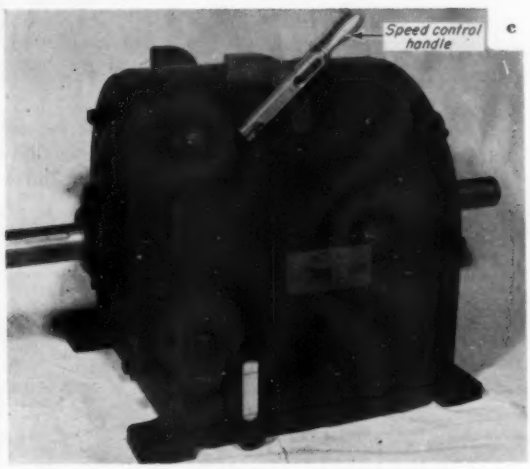
Housed units are available for foot mounting and coupling to the prime mover. Housings may be provided with scoops for mounting a standard foot-mounted electric motor (see Figure 12b). Another variation is the housed unit made for mating with a standard flange-mounted motor.

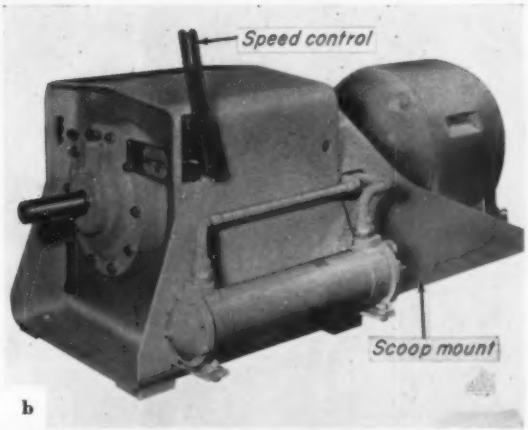
Many of the fluid couplings and torque converters intended for use with internal combustion engines are designed to mount directly to the back of the engine to make a prime mover package. These are driven from the flywheel and bolt directly to it. Here the user usually has the option of purchasing the unit complete with standard SAE housing for the unit with a charging pump and perhaps an oil cooler for the fluid, or as a stripped unit which is only the basic operating members. Then, housing and charging pump must be provided by the user. Torque converters are also available for amidship mounting in vehicles, Figure 14. This means the unit can be placed anywhere between the engine and transmission and coupled to them by universal shafts.

For vehicle use, converters and couplings are also available as part of a complete automatic transmission package, Figure 15. Except for size, these transmissions are much like those available on passenger cars. One major difference is that more control is retained by the vehicle operator. He can select the desired gear ratio at any time. Control is not by vehicle speed and throttle opening.

Other available variations include units with discon-







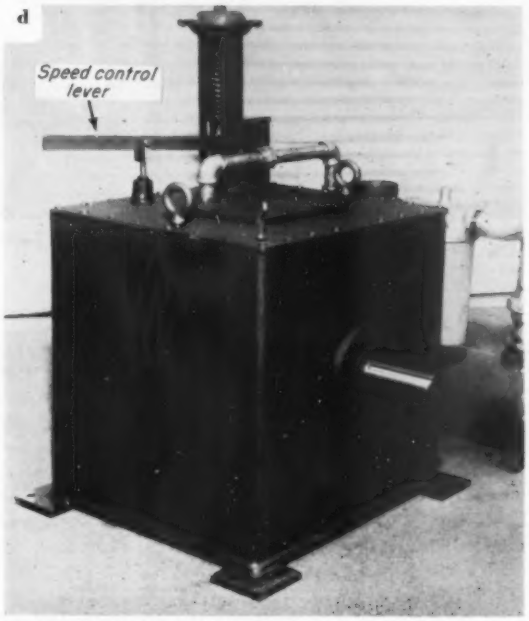


Fig. 12. Variable-speed fluid couplings. Cross-section, *a*, shows how a scoop tube controls oil level in the working members and thus torque absorption and speed. These are all foot mounted units designed to couple to input and output shafts with flexible shaft couplings. Scoop mounting for the drive motor is provided as an integral part of unit *b*.

nect clutches built into the same housing, reduction gearing integral in the converter housing, or special reduction gear units for bolting directly to the back of the converter housing, and an overrunning or free-wheeling clutch to couple the turbine mechanically to the impeller any time turbine speeds exceeds the speed of the pump. This lets the prime mover be used for braking.

Sizes: Actual physical sizes of the fluid couplings and torque converters covering the horsepower range given is from approximately 6 in. to more than 3 ft. in diameter. This dimension is for the unit proper. It does not relate to the case or housing which may surround it. Weights range from a few pounds to many tons for large, housed units. For example, a 2500 hp, variable-speed, fluid coupling weighs 7½ tons. This is in a large housing for floor mounting and includes a 310 gallon fluid charge.

Combination Drives

To modify the overall characteristics of a hydrodynamic drive, it may be combined with other drive components. Simplest of these is the converter-lockout clutch combination. When output shaft speed ap-

Fig. 13. Fluid couplings for mounting directly on motor shafts incorporate V-belt sheaves to simplify drive connections.

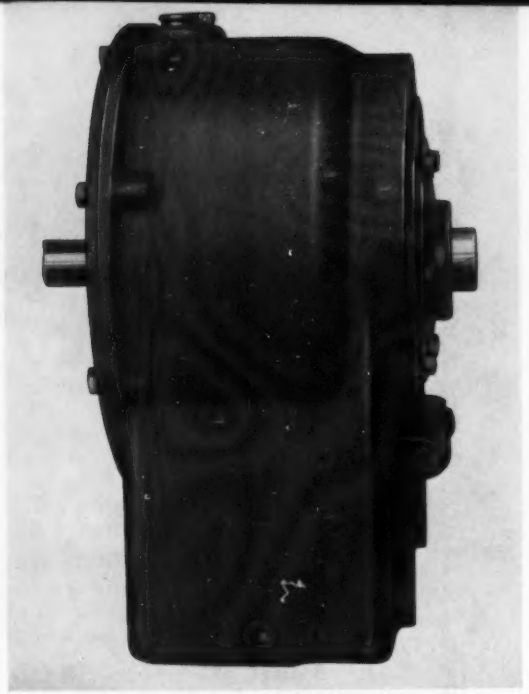


Fig. 15. Torque converter-automatic transmission package for large trucks.

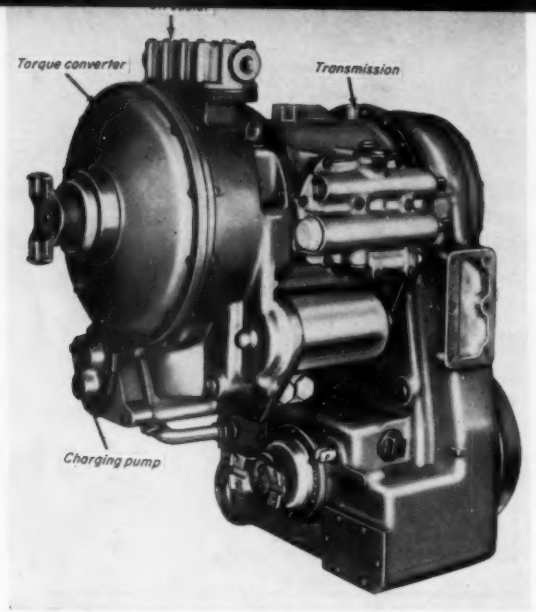


Fig. 14. Torque converter unit for amidship mounting on a vehicle has integral sump, and charging pump. Stub shafts are connected to engine and transmission.

FLUID COUPLINGS *continued*

proaches input shaft speed, a mechanical clutch is used to lock the two shafts together to give 1:1 speed and torque ratios. This also increases efficiency of the drive.

Wound-rotor ac motors, torque converters, lockout clutches, and variable-ratio gear transmissions have been combined to give a substantially constant horsepower drive over a wide speed range.

Split torque drives where a percentage of the input power is transmitted through a torque converter and the remainder through a direct drive have also been used. These combine characteristics of torque converter and direct drive. When this is done, the final characteristic depends on the percentage of power transmitted in each way. While such a system eliminates disadvantages of torque converter drive, it also eliminates advantages. ▲▲▲

HYDRODYNAMIC DRIVE MANUFACTURERS DIRECTORY

Manufacturer	Type		
	Fluid Coupling	Variable-Speed fluid coupling	Torque Converter
Allison Div., General Motors Corp.			X
American-Standard Industrial Div.	X	X	
Clark Equipment Co., Automotive Div.			X
Dana Corp.			X
N. A. D'Arcy Co.		X	
Fluid Drive Engineering Co.	X		
Fuller Mfg. Co. Transmission Div.			X
Liquid Drive Corp.	X	X	
Long Mfg. Div. Borg-Warner Corp.			X
National Supply Co.			X
Rockwell-Standard Corp. Transmission and Axle Div.			X
Torque Converter Div., Little Beaver Industries Inc.			X
Twin Disc Clutch Co., Hydraulic Div.	X		X

Acknowledgement

Co-operation of the following companies in providing information for use in this article and the noted illustrations is acknowledged with thanks.

Allison Div., General Motors Corp. (Fig. 15) ..... Indianapolis 6, Ind.

American-Standard Industrial Div. (Figs. 12a, 12b, Table I) ..... Detroit 32, Mich.

N. A. D'Arcy Co. (Figs. 11, 12d) ..... Huntington Park, Calif.

Fluid Drive Engineering Co. (Fig. 10) ..... Wilmette, Ill.

Fuller Mfg. Co., Transmission Div. (Figs. 3a, 6) ..... Kalamazoo, Mich.

Liquid Drive Corp. (Fig. 12c) ..... Holly, Mich.

Long Mfg. Div., Borg-Warner Corp. ..... Detroit 12, Mich.

W. C. Robinette Co. ..... S. Pasadena, Calif.

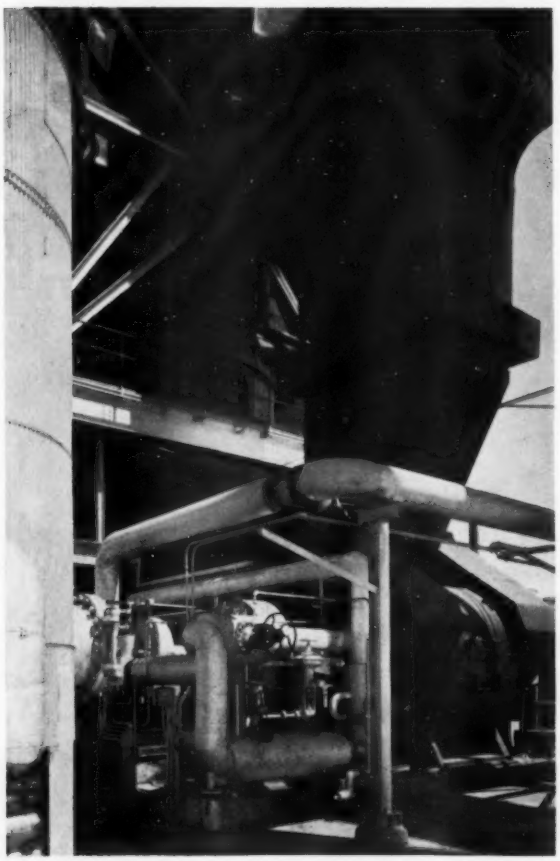
Rockwell-Standard Corp., Transmission and Axle Div. (Figs. 2b, 9a, 14) ..... Detroit 32, Mich.

Torque Converter Div., Little Beaver Industries Inc. (Fig. 3) ..... Cleveland 14, Ohio

Twin Disc Clutch Co., Hydraulic Div. (Figs. 8, 9b, 13) ..... Rockford, Ill.

DESIGN
IDEAS
FROM THE FIELD

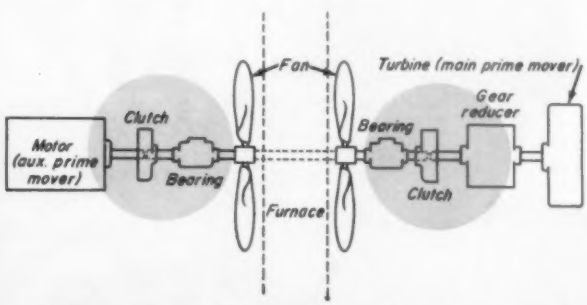
Air clutches accommodate shaft elongation



SHAFT EXPANSION can damage bearings and reduction gears. In a West Coast oil company's new steam plant, shafts of two 70-in. draft fans would elongate $\frac{3}{8}$ to $\frac{1}{2}$ in. while reaching operating temperatures during startup. One fan, a forced draft fan, helps boiler combustion, while the other, an induced draft fan, pulls hot gases from the furnace.

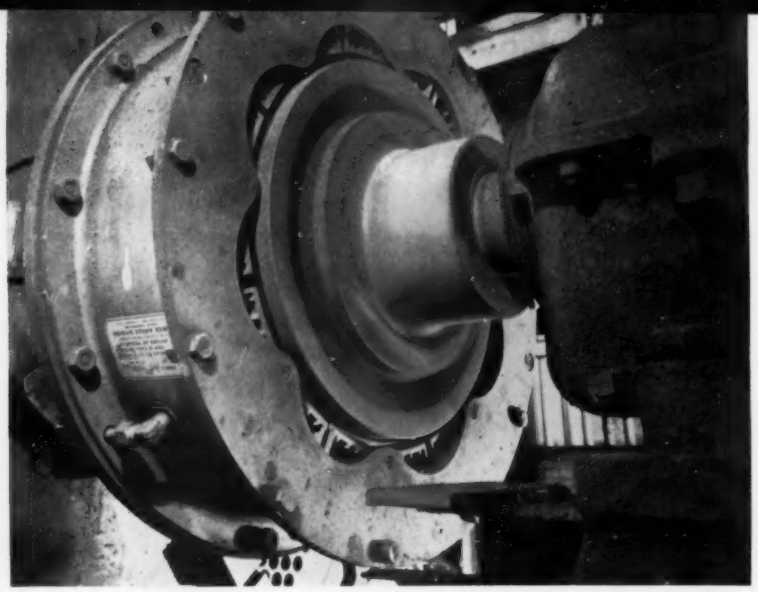
Plant designers at Tidewater Oil Co.'s Avon, Calif., refinery took care of the thermal expansion by using air-actuated clutches to transmit power to the fans. These air clutches can compensate for lateral motion by quick disengaging and engaging. They eliminated the need for expansion joints and complex bearing design.

Four of these clutches, specifically designed for heavy duty, couple main and auxiliary power sources to both dual-driven fans. The forced draft fan clutches have a torque rating of 65,000 lb-in. at 75 psi and



DRIVE ARRANGEMENT (above) of prime movers, clutches, and fans in oil company steam plant (left).

IDEAS
continued



AIR CLUTCH's quick connect and disconnect compensates for shaft elongation. Open design dissipates heat from slip action.

AIR CLUTCHES *continued*

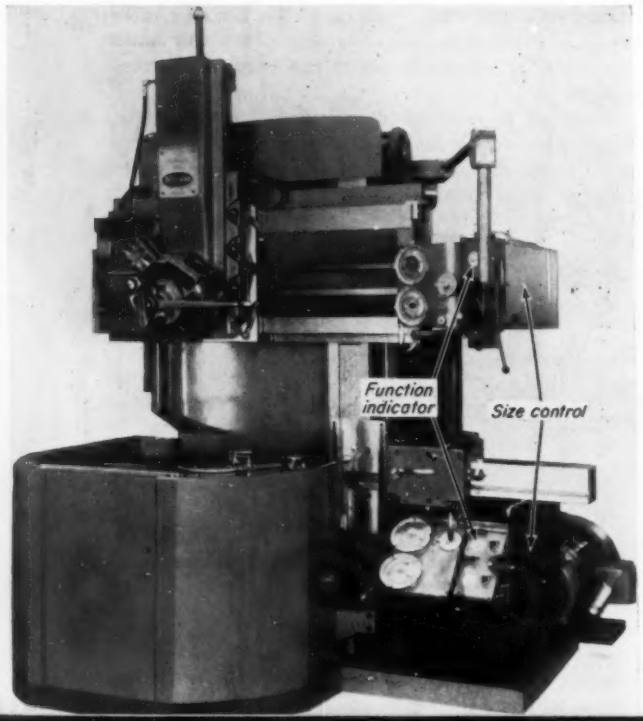
100 rpm; the induced draft fan clutches are rated at 186,000 lb-in. at 75 psi and 100 rpm.

Main and auxiliary power sources are at opposite ends of the shafts. The main prime movers for both fans are steam turbines. For the forced draft fan, a 450 hp turbine runs at 3540 rpm through a gear reducer to produce output speed of 880 rpm. The induced draft fan turbine, 1250 hp at 3470 rpm, drives through a gear reducer for output speed of 690 rpm. Auxiliary power on the forced draft fan is from a 450 hp, 880 rpm electric motor, while another 1250 hp steam turbine is the auxiliary drive for the induced draft fan.

The clutches are independently mounted. Each clutch drum is mounted on the driven fan shaft. The clutch element assembly is mounted on the driving shaft. As the shaft heats up, an automatic timer disengages the clutch at regular intervals, allowing the drum to move further into the clutch element assembly. Friction shoes then regrip the drum in the new position, without interrupting speed or efficiency.

Open construction of the clutch element permits passage of cooling air and rapid heat dissipation from the friction surface. The engaging action permits gradual fan startup through controlled slip-clutch action.

This action also makes switching from main to auxiliary power more efficient. Since the shaft is rotating at the speed provided by the main power source, the clutch coupled with the auxiliary source slips until the auxiliary assumes full power. This gives a smooth switch with no loss of time. ▲▲▲



Stops clutch action within .0003 in.

YOU NEED precise control of clutch disengagement to automatically stop machine cutting heads within close limits. A size control developed by Bullard Co., Bridgport, Conn., gives repetitive accuracy of .0003 in. to horizontal and vertical motions.

This control, *Size-Au-Trol*, will be standard on all Bullard *Dynatrol* vertical turret lathes. With it, the operator won't have to size work manually.

Here's how it works:

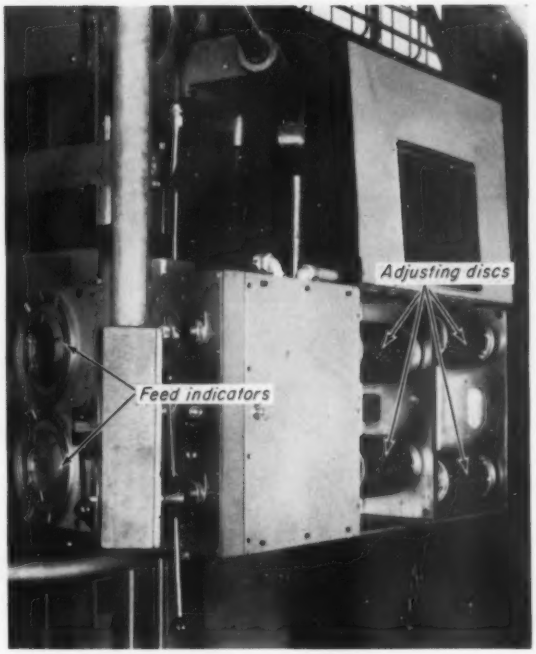
Electro-mechanical devices positively link the control system with the rapid traverse and feed drive to the cutting heads. There are four rotating drums, one pair above the other. One pair controls horizontal motions, the other, vertical. One drum in either pair

is for fine adjustment, the other for coarse adjustment. The fine drums are geared directly to the feed screws; the coarse drums are driven by the fine drums through worm gearing.

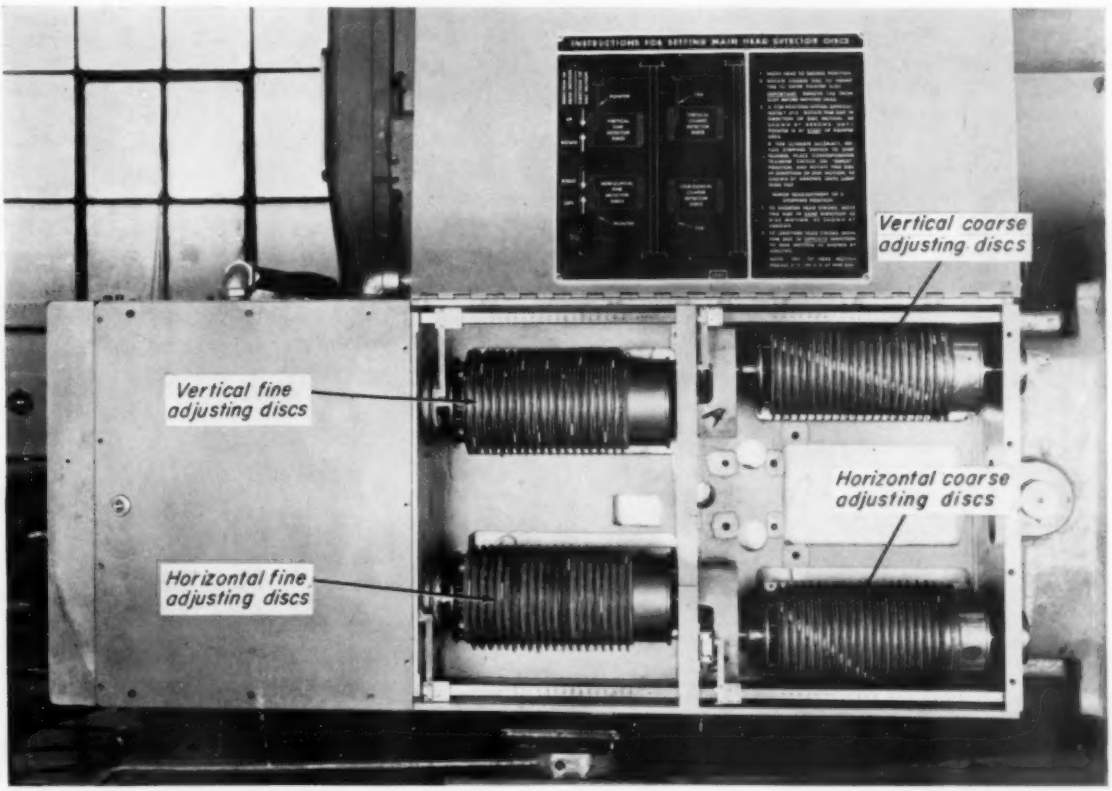
Each drum carries 20 to 40 adjustable detector discs. These discs are flat circular plates, each having a single cam to contact a switch as the drum rotates. The switches actuate a solenoid valve, exhausting the hydraulic pressure engaging the directional clutch. This disengages the feed screw, stopping motion of the head. Two discs on each drum are limit stops for extremes of head travel.

The position of each cam is adjusted by rotating the disc. The discs are spring-loaded and held in place by friction. In setting up the machine, each pair of discs is rotated to control either horizontal or vertical motion of an operation in the machining sequence. It's possible to make extremely fine adjustments, since a .012 in. rotation of the OD of the fine drum corresponds to .001 in. head travel. One revolution of the fine drum covers 1 in. of head travel; one revolution of the coarse drum, 100 in. of head travel.

Function indicator dials are numbered to match numbers of the detector discs. All the operator has to do is manually engage movement of the heads in the proper direction with a control lever. After each operation, a stepping relay indexes the drum to the next operation, and the operator again engages the proper feed. ▲▲▲



SIZE CONTROL (above) on vertical turret lathe links with rapid traverse and feed drive to the cutting heads. In closeup of adjusting discs (below) notice how easy it is to set the controls. One turn of a fine drum covers 1 in. of head travel.



IDEAS
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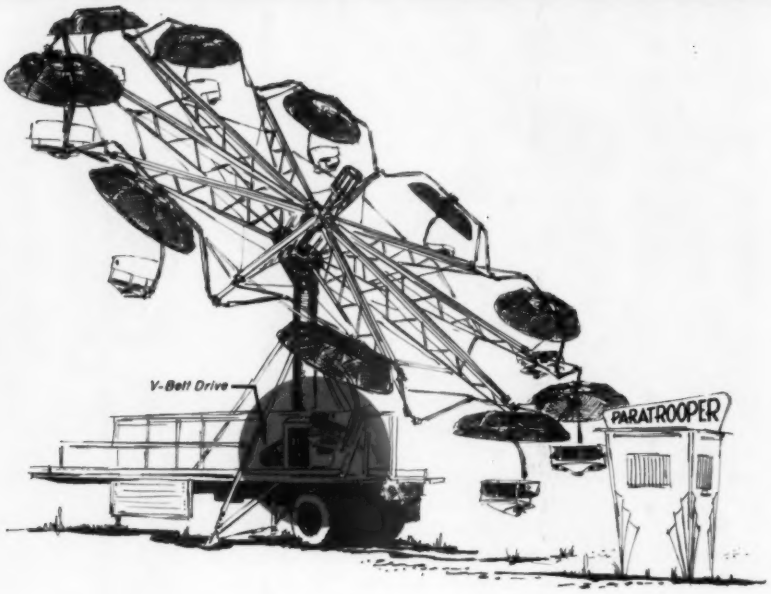


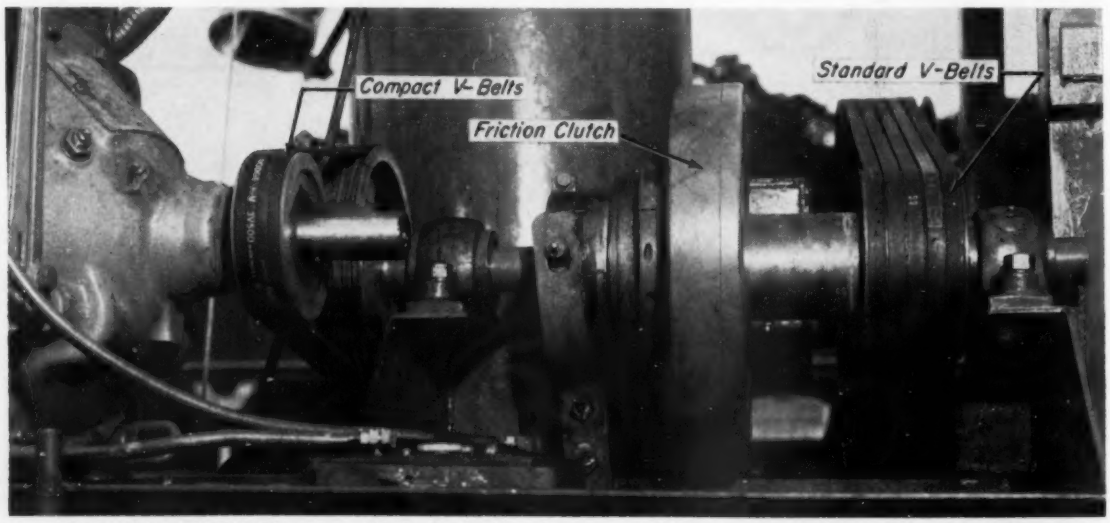
Compact V-belts handle high inertia

A PARATROOPER, grounded by clutch failure, was returned to action by a new compact V-belt drive. The *Paratrooper* is actually a carnival ride at the Oregon State Fair. Its original drive had an engine clutch that lasted just a few weeks because of the high inertia load of the heavy superstructure.

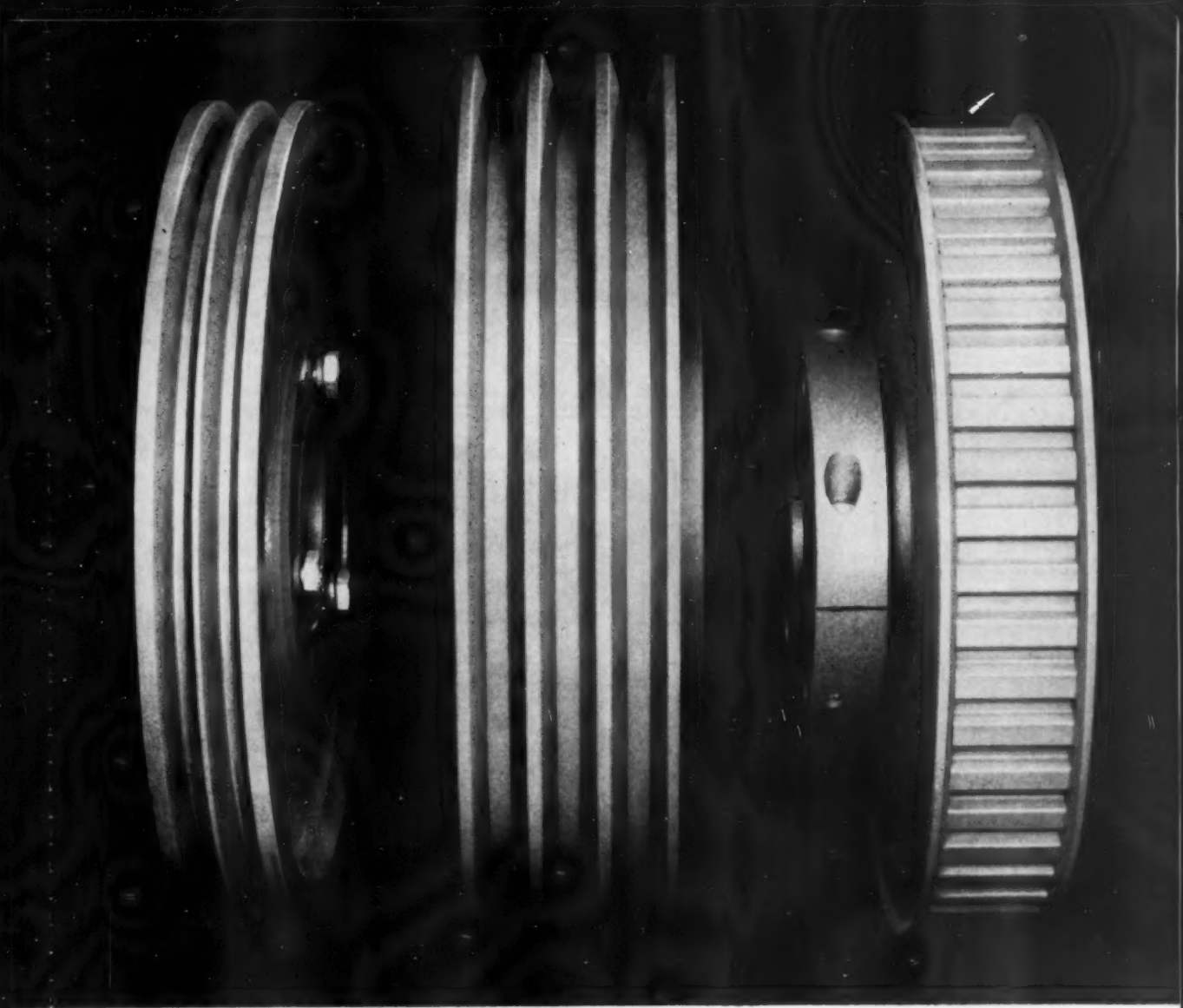
This drive was replaced by a new one with compact V-belts and 4-groove sheaves. The belts are narrower and stronger, the sheaves are smaller and lighter. They're used for the first stage of speed reduction from a Continental 162 engine developing 32 hp at 1900 rpm.

The compact V-belts transmit power to a countershaft supported by two roller bearing pillow blocks. A friction clutch on the countershaft engages a standard 5-groove V-belt drive which operates the ride through a gear reducer. In the clutch, selected for its ruggedness, pressure on the friction disc is developed by a circle of steel balls forced into a wedge-shaped groove by the sliding cam.

The new drive solved all problems. The compact belts are strong enough to stall the engine without breaking, or even slipping. Although these belts carry the same horsepower as the larger 5-belt drive on the countershaft, they take up less space. The drive worked so well Hrubetz & Bushnell, builder of the Paratrooper, is using it on several other carnival rides. ▲▲▲



CARNIVAL RIDE DRIVE uses both standard and compact V-belts. Photo courtesy Dodge Mfg. Corp.



THE NEW MULTI-WEDGE DRIVE SHEAVE | MULTI-V DRIVE SHEAVE | POSITIVE DRIVE PULLEY

FIRST, LOOK AT THREE

Measured by horsepower handled, the three wheels shown are the same. But Multi-V (long the industry favorite) is bulky, as compared with the new lighter, equally strong Multi-Wedge Drive. And the Positive Drive combines advantages of the chain and gear with the advantages of the belt.

For all three, even in fractional sizes, Worthington supplies the tapered, split QD hub with the Golden Screws. Or, of course, it supplies bored-to-suit hubs for special applications. And for every drive, from 1/20 hp to 600 hp or more, the proven Worthington-Goodyear belts are supplied. In fact, the QD hub plus these belts in any of the above three drive types make them most compact, flexible and long-lived.

Which drive you choose is up to you. But don't toss a coin. To help you decide, Worthington has just issued new engineering manuals on all three drives, including "how-to-figure-it" information. For low horse power drives, get the "Fractional HP" manual. Ask the Worthington distributor listed in the Yellow Pages for the manual(s) you want. Or send the coupon listed below.

WORTHINGTON CORPORATION
Section 79-33, Oil City, Pa.

Please send me the engineering manuals checked here.

☐ Multi-Wedge ☐ Multi-V ☐ Positive Drive ☐ Fractional HP

NAME_____

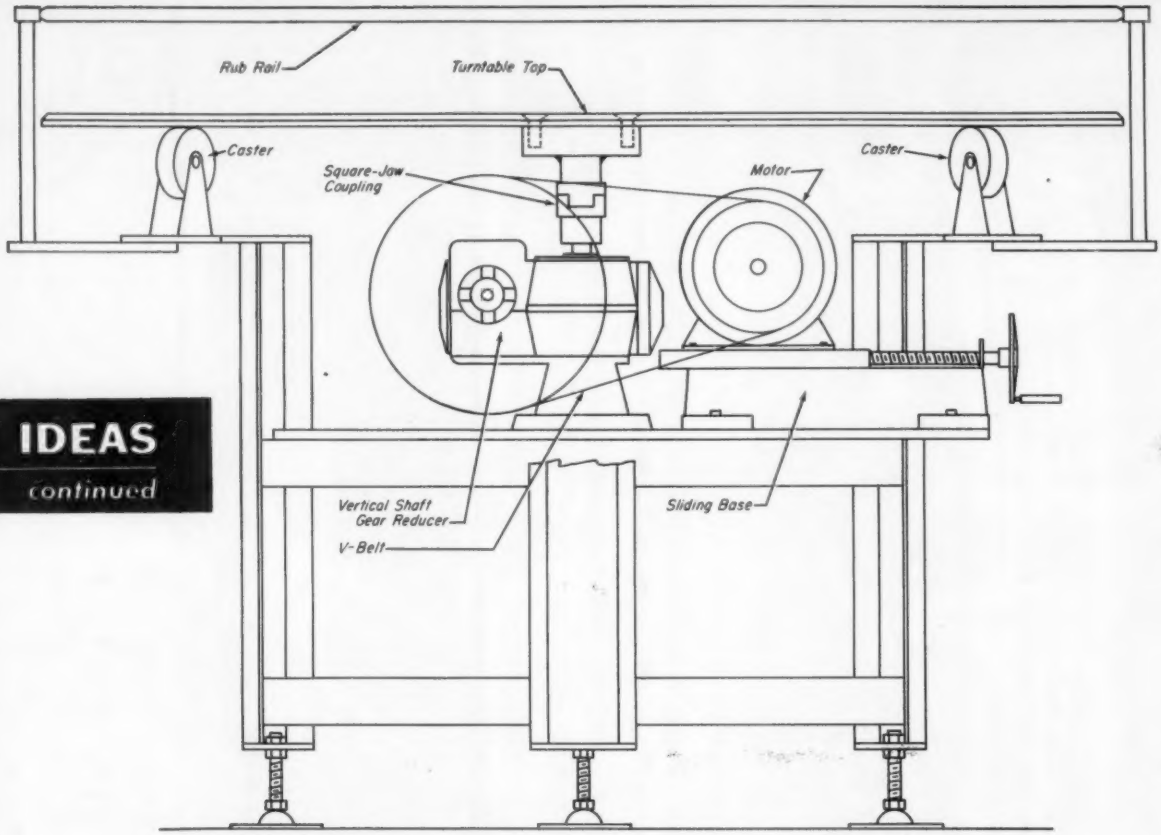
COMPANY_____

STREET_____

CITY_____ STATE_____

WORTHINGTON

Circle No. 34 on Reader Service Card

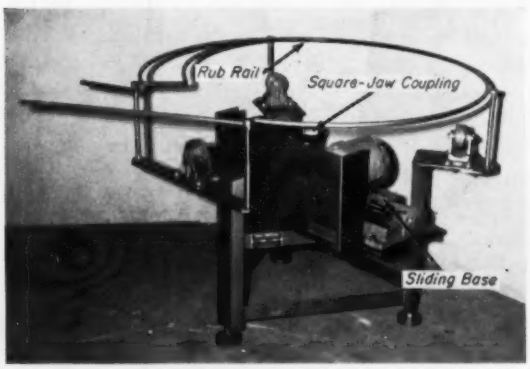


TURNTABLE DRIVE is simple, consists of motor, variable-speed pulley, and gear reducer.

Simple turntable design proves best

DESIGN SIMPLICITY paid off in a better power turntable produced at less cost by Stone Conveyor Co., Inc., Honeoye, N. Y.

The turntable—basically a round plate, base, and power unit—is used in the glass industry. Bottles, after inspection, enter the turntable from a flat-top conveyor. They're guided by a rub rail and rotate within reach of workers who put them into cases.



SIMPLICITY is evident when top is removed.

The turntable top is supported by three molded phenolic roller-bearing wheels supported in standard caster assemblies. They give quiet-running support, as well as surface evenness despite minor variations in the plate. The top, 46 in. in diameter, is machined from ½-in. steel plate. One half of a square-jaw coupling is welded to a plate bolted to the top.

A vertical shaft gear reducer transfers power and serves as a center pin. It's connected to the turntable by the other half of the square-jaw coupling, letting the top rotate on the wheels. This coupling permits the top to be removed by just lifting it off. The reducer is driven by a variable-speed pulley on the motor, which is mounted on an adjustable sliding base. Speed of the turntable is variable from 1.33 to 4 rpm.

The inside edge of the rub rail has teflon adhesive-backed tape to reduce friction with the bottles. Previously, nylon or teflon strip was attached by recessed screws. The tape can be installed in minutes, is easily replaced when worn. ▲▲▲

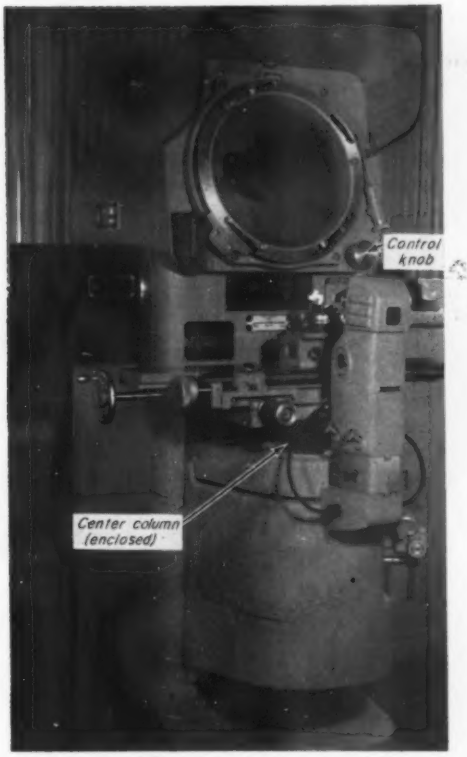
Direction/speed control simplifies drive

ONE CONTROL KNOB selects the direction and governs the speed of the work table of a floor model optical comparator made by Jones & Lamson Machine Co., Springfield, Vt. Table location can be measured within .0001 in. for simultaneous positioning and gaging.

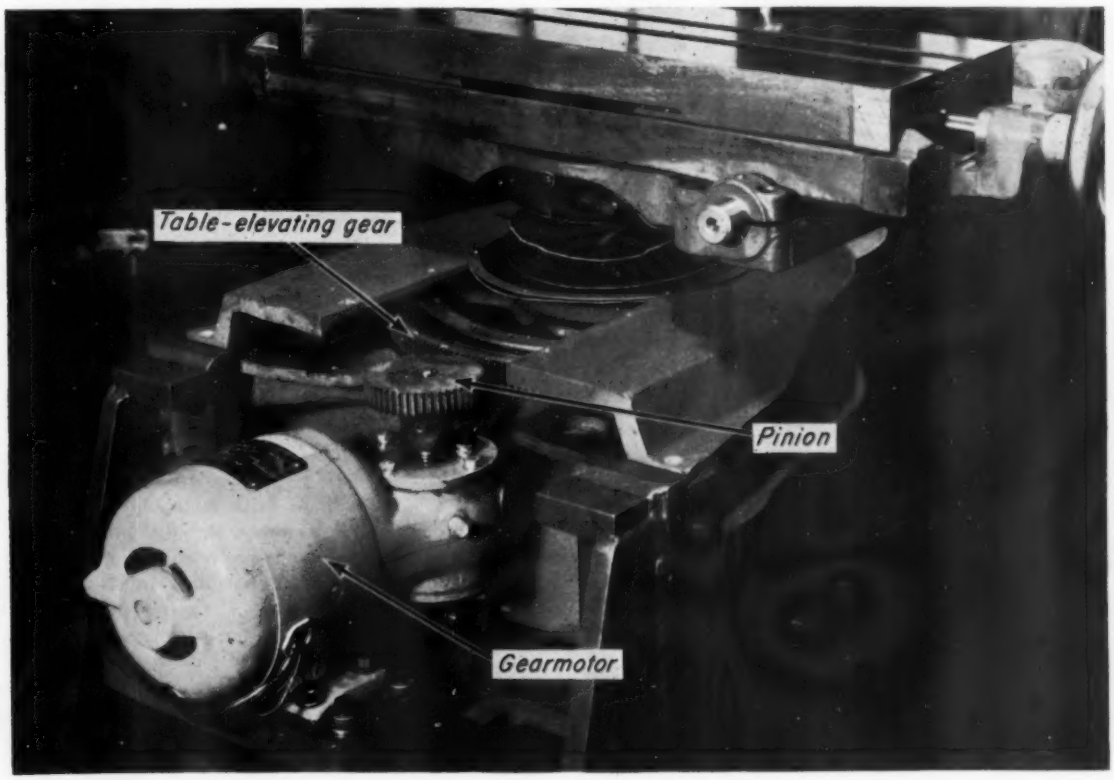
The table's elevating drive has a variable-speed, fractional-hp, right-angle gearmotor; limit switches for vertical travel; rectifier tubes and other speed and reversing controls.

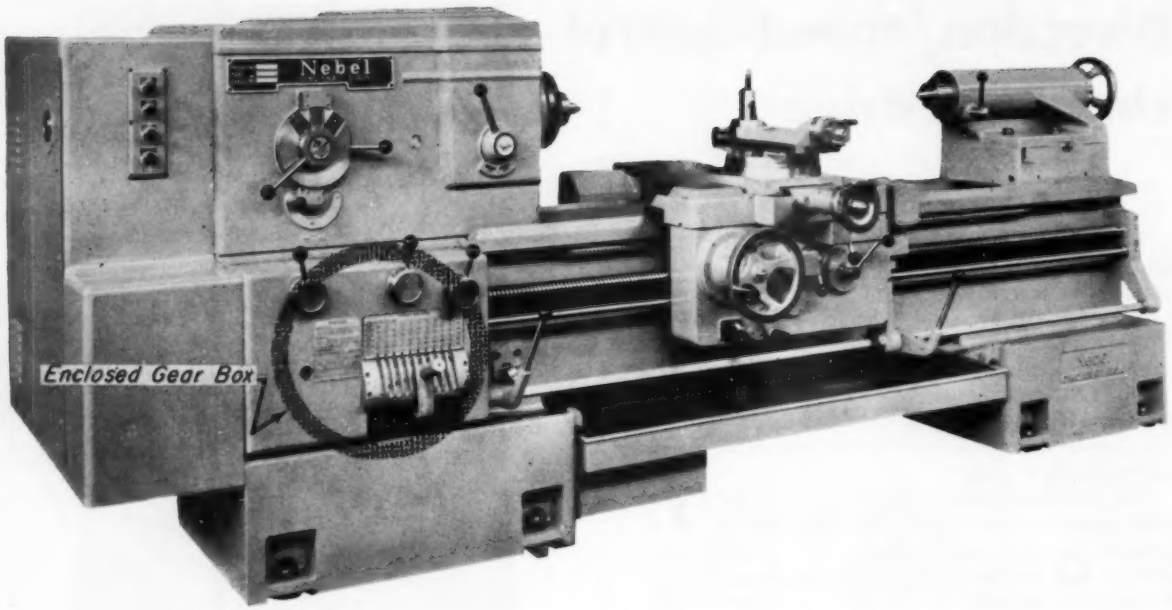
The gearmotor has a pinion gear on its output shaft which engages a large, threaded table-elevating gear on the center table column. The elevating gear runs on balls so that a thrust ball bearing is formed by the gear, the balls, and the basic machine casting. Threads on the table column are so precise a graduated ring on the elevating gear can measure table location within .0001 in.

The elevating control has a single spring-centered knob. Rotating it counterclockwise raises the table, rotating it clockwise lowers it. The greater the rotation, the faster the speed. ▲▲▲



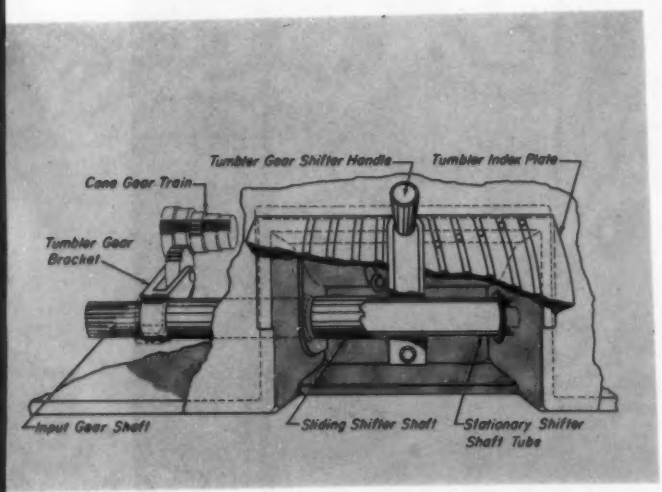
SINGLE KNOB on optical comparator controls both speed and direction of the work table (above). Drive detail is shown below.





Quick-change gears are totally enclosed

IDEAS *continued*



OIL SEALS on shifter shaft permit housing.

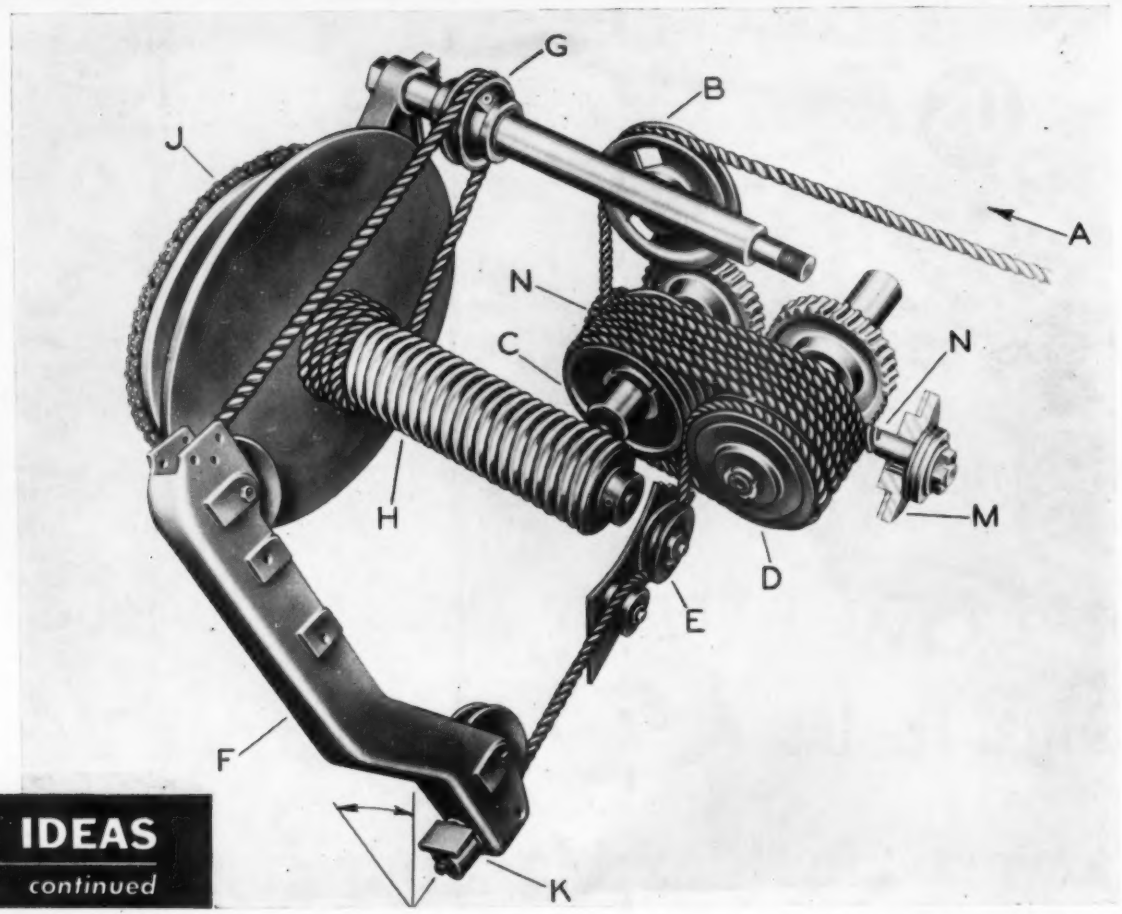
A TOTALLY-ENCLOSED gear box on a new engine lathe combines the advantages of total enclosure with those of simple, reliable tumbler gears. The few parts required by an oil seal and telescopic shifter shaft combination makes it possible.

The enclosed housing keeps out dirt and chips. The quick-change gears give 60 feeds from .0027 to .192 ipr, and 60 thread changes from 1 to 72 threads per inch. Filtered oil from the headstock provides automatic lubrication.

You select a feed or lead by moving the shifting handle to the desired number on a direct reading tumbler index plate. The tumbler gear locks in place with a positive catch. In low spindle speeds, feeds and leads can be changed without stopping the spindle.

A constant-speed main drive motor supplies up to 20 hp through a multiple-disc clutch and brake. There are 18 gear-driven speeds, selected from a direct reading color index and controlled by two levers and color-keyed speed plates. Selective gear design provides speeds up to 1500 rpm while engaging only the gears required. The headstock has wide-faced, shaved and hardened gears, with short, heavy, multi-splined shafts.

The lathe, Model SD 2516-20, is manufactured by Nebel Machine Tool Corp., Cincinnati, Ohio. ▲▲▲



IDEAS
continued

HOW IT WORKS: Cable pulls load in direction of arrow (A). The cable travels over the fair-lead sheave (B), down to the first power drum (C), then to the second power drum (D), and successively around these drums down to the start of the level winding mechanism (E). The cable then goes up through the level winding bracket (F), over the sliding sheave (G), and finally to the storage drum (H). The storage drum is driven by the winch worm shaft (N) through the friction clutch (J). As the sliding sheave (G) moves back and forth, it pivots the level wind bracket (F) at point K. The safety brake (M) is automatic.

Variable-slip clutch keeps load constant

SEPARATION of power and storage in a reversible winch provides constant (1) load, (2) speed, (3) torque, and (4) horsepower. The winch, Model CL rated at 12,000 lb, is made by Braden Winch Div., Motor Products Corp., Broken Arrow, Okla.

Most winches combine power and storage in one drum. In the CL winch, two power drums do the pulling while a large-capacity storage drum takes up the cable.

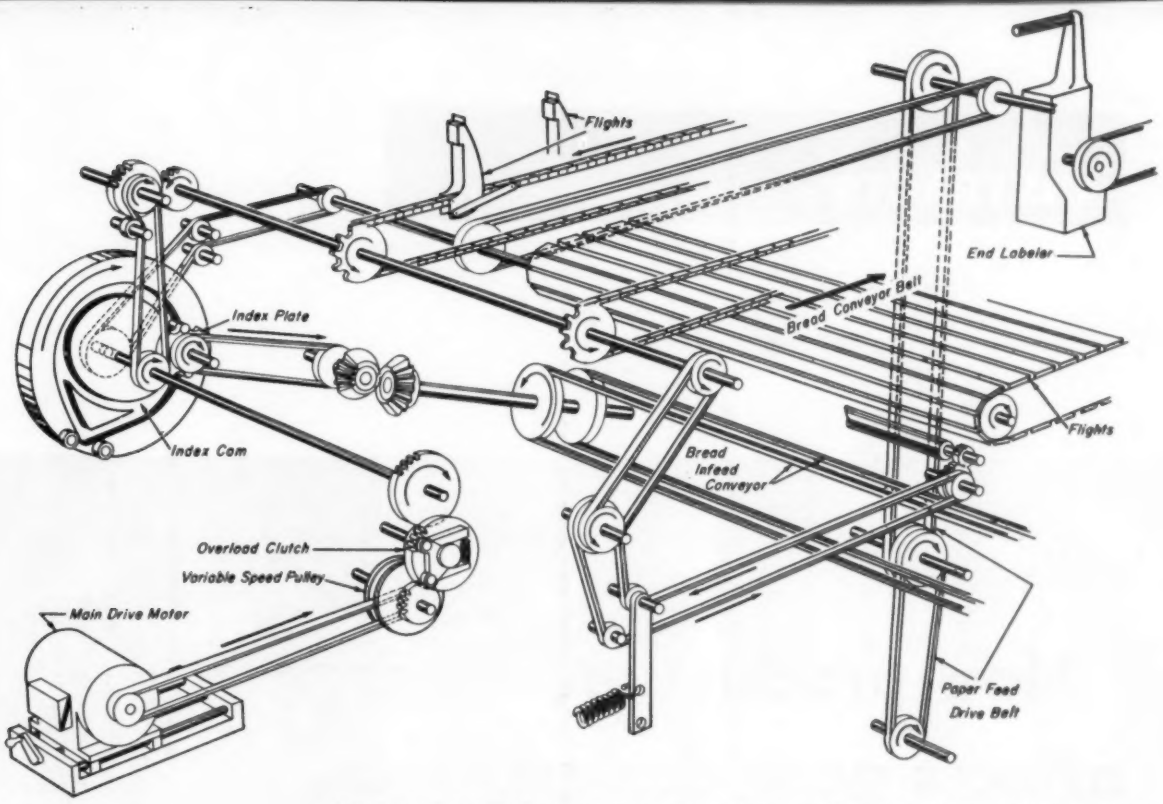
The storage drum friction clutch, driven by a worm shaft, also acts as a drum brake. It slips constantly, supplying just enough tension on the cable between storage and power drums. This provides the friction between the cable and power drums needed to work the winch like a manila rope capstan. The two power drums are driven by gears which in turn are driven by a worm.

Speed and load remain constant because layers of cables do not build up on the power drums. At the same time, a level winder protects the winch, cable, and load by winding the cable evenly on the storage drum.

For safety, an automatic, variable-pressure, worm brake is self-adjusting to wear and load. The load on the cable applies brake pressure, and the greater the load, the greater the brake resistance. In case of power loss during operation, the brake locks automatically until full power is restored.

An automatic brake pressure release, operated by reverse input torque, allows any load to be lowered with no more effort than in a conventional, non-reversing worm-geared winch. It's safer, though, since the brake is fully engaged the moment input reverse power stops.

Because of its high overall efficiency of 70 percent, it runs off a small motor and pump. ▲▲▲



MAIN DRIVE ONLY. A separate drive adjusts machine for different loaf lengths.

Direct drive eliminates backlash

A BELT-DRIVEN GEAR DRIVE practically eliminates backlash in a large bakery machine that wraps, seals, and labels up to 75 loaves of bread a minute. Backlash—a problem in high-speed machines with inherent imbalances—had to be eliminated in this one, which handles temperamental polyethylene film.

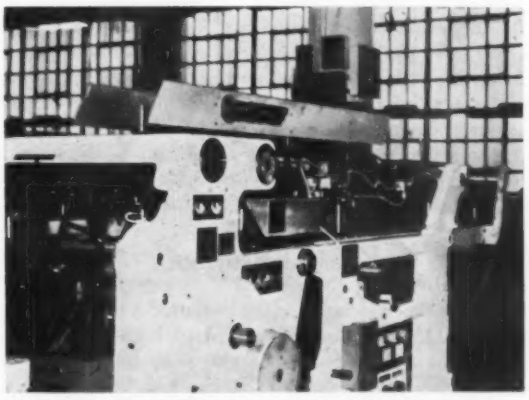
An earlier model used a gearbox drive. It was more compact, but the backlash couldn't be brought within tolerable limits.

A 1200-rpm 1½-hp motor (3 phase, 220 v) is stepped down to about 60 rpm at the main drive shaft through a V-belt-driven variable-pitch pulley and two step-down gears. There's a spring-type overload clutch on the first gear to prevent damage to expensive parts if the machine jams.

The main drive, through belt takeoffs, powers the bread conveyor belt, the labeling section, and the paper feed and supply drives. Through a cam and index plate, which turns through one-half revolution for every revolution of the main shaft, it also drives the mechanism that feeds the bread loaves into the machine.

A separate ⅛-hp, 155-rpm motor (3 phase, 220 v) adjusts the machine to handle different loaf lengths, in response to pushbutton signals. No height or width adjustment is made, as the poly feed mechanism automatically responds to these dimensions. This is because dimensions vary from loaf to loaf. The machine wraps baked goods from 3 to 8 in. wide, 6 to 17 in. long, and up to 6 in. high.

The machine and drive were designed by engineers of American Machine & Foundry Co.'s Bakery Div., Brooklyn, N. Y. ▲▲▲



BAKERY MACHINE using no-backlash direct drive.

How production affects gear design

By A. HARDY, *Detroit Transmission Div., General Motors Corp.*

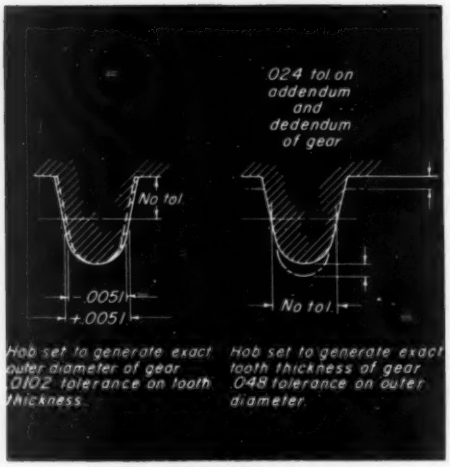


FIGURE 1.

GOOD GEAR DESIGN means more than function and durability. It considers whether the gear can be produced economically within reasonable tolerances at a desirable rate.

The quality gear is usually machined by a roughing tool, such as a hob, shaper cutter, or broach. If the gear requires finishing, its design should include clearance for a rotary shaving cutter, rack shaver, or a gear grinding wheel.

For example, let's consider a flywheel ring gear with 176 teeth, 12 diametral pitch, and 12° pressure angle. Concentricity and accuracy of the major diameter are prime considerations. In operation, the gear is vulnerable to a wide tolerance in center distance. There's danger of tip to root interference with excessive plus tolerances, and a lack of involute contact ratio with too much minus tolerance.

Full-topping hob

A full-topping hob is best for producing this gear because it can qualify the major diameter along with the profile and root. This hob has 6 threads for economical production. Because 6 is not a multiple of the 176 teeth in the gear, errors are averaged out by hunting teeth. This blending out of errors also adds tolerances.

The actual dimensional tolerance of the hob tooth thickness at a specified depth is held to .0015 in. The gear, when cut, is forced to accept this tolerance plus errors in hub and spindle runout, hob O.D. runout, variation in depth of form, flute spacing, lead error, and thread spacing.

It's difficult to treat these errors individually. The hob runout and depth of form affect the major and minor diameters directly; indirectly, they add to the lead error of each thread on the hob. Lead errors add tolerances to the tooth thickness on the pitch diameter of the part. The possible errors add up to effective dimensions which give the designer two choices (Figure 1).

If it were possible to set each hob so it would generate an exact outer diameter on the gear, the effective tolerance on this hob would be .0102 in. on the tooth thickness along the pitch diameter. The other possibility is to set the hobs to produce the exact tooth thickness on the gear. This would call for a .048 in. tolerance on the major and minor diameters of the gear.

The tolerance on the tooth thickness in this case

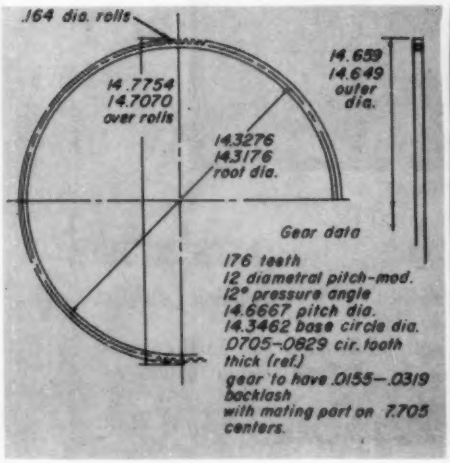


FIGURE 2.

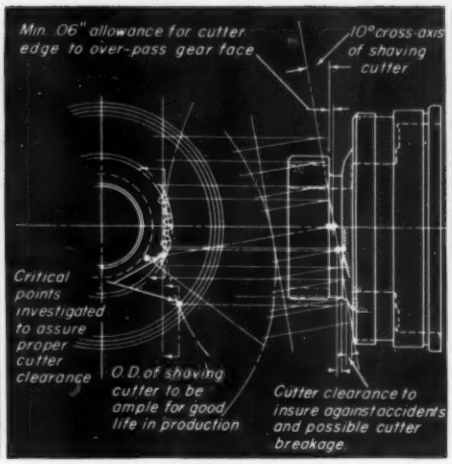


FIGURE 3.

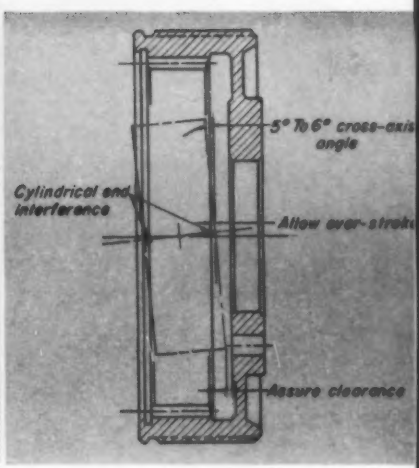


FIGURE 4.

was relatively unimportant, as it involved backlash of a gear not in a torque-flow circuit. The gear designer chose to hold the outer diameter, since a closer tolerance there would insure proper involute contact ratio.

He was compelled to allow a .0124 in. tolerance on the circular tooth thickness, .0164 in. on backlash with mating gear, and .0684 in. on the overpin size. These wide tolerances (Figure 2) were the price for confining the outer and root diameters to .010 in.

Shaper cutting and shaving

Another type of gear (Figure 3) carries more torque, requires more life, and is expected to be reasonably quiet. This gear shows how cutting tools can influence design.

Obviously, it could not be hobbed—there is no hob runout clearance. The answer was a shaper cutter. The undercut behind the gear should be wide enough to allow for shaper cutter overstroke and provide space for chips. The minimum width of runout grooves in shaper cutting is 5/32 in.; the minor diameter of the undercut should clear the outer diameter of the cutter. A more liberal undercut helps prevent accidents and expensive cutter breakage.

The shaving cutter's ability to cut depends on its cross-axis relation to the work. On external gears, the angle is normally 8 to 12 degrees. At 8 degrees, the cutting action is just beyond the border of cold working. As the cross axis increases, the cutter works more freely. Beyond 12 degrees, the cutter tends to dig.

Since clearance between gear teeth and shoulder is critically small in the gear in Figure 3, there's danger of inadequate shaving cutter stroke. This stroke, whether it's conventional (along the axis of the work) or diagonal (at some angle to it) is very essential. The stroking action of the shaving cutter will wipe out the hollow lead resulting if only radial feed were used.

Figure 4 shows an internal, closed-end gear which cannot be broached. Here again we must use the shaper cutter for the rough cut and a rotary shaving cutter for finishing. Unlike the external gear, the internal sets a fairly low limit on cutter size.

Choosing a shaving cutter and providing cutter clearances is much the same as for the external

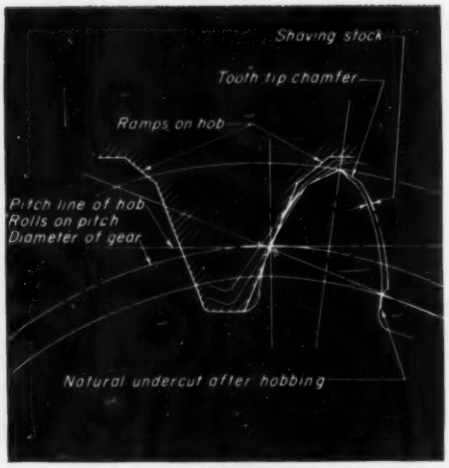


FIGURE 5.

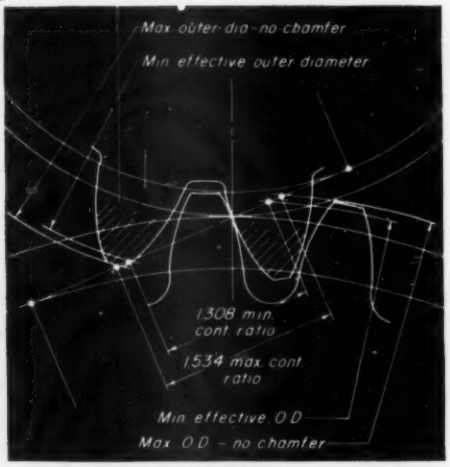


FIGURE 6.

gear. The main differences are the limited outer diameter of the cutter and, because the closed end is so near the teeth, a lower cutting cross axis of 5 to 6 degrees.

Unlike the action in external gear shaving, the pitch cylinder of the internal gear tends to interfere with the pitch cylinder of the shaving cutter. This mismatch is like a shaft operating off-axis to its bushing. It causes crown shaving of the lead, instead of the hollow lead in external gear shaving. Again, the conventional or diagonal traverse shaving will remove this natural crown.

Where lack of space prohibits oscillation, or if the radial feed shaving is preferred, you must modify the cutter to remedy this effect.

Broaching

The internal gear in Figure 4 can be redesigned for broaching. The closed-end design could be eliminated by isolating the flange from the gear.

However, attaching the flange is often a problem. It usually involves added length, an added operation (staking or welding), added machining (cutting a spline or snap ring groove), and added parts (snap rings, dowels, or bolts). Some of this added expense may be eliminated by making the flange of cheaper steel, such as SAE 1010 or 1008, making it less expensively, such as by stamping, and with little or no heat treat.

Gear broaches produce gears more uniformly than a multiple number of shaper cutters. An internal gear designed for broaching has ample clearance for the shaving cutter, so that lack of space is never the restricting factor on the cross-axis angle. The broach will produce an undercut for shaving. This undercut is difficult and impractical with a shaper cutter.

On the other hand, the broach has its disadvantages. Generally, a broach costs from $5000 to $7000. A shaper cutter costs about $85. Also, the broach is more sensitive to variations in the composition of steel in gear blanks. It may sometimes drift, tear, or snowball.

Semi-topping hob

On external gears, a tooth-tip chamfer is included in the hobbing operation (Figure 5). The tool, a semi-topping hob, in effect has a double pressure angle. The main body of the hob generates the involute. A ramp produces another short involute of a higher pressure angle with wider tolerances in form as well as location. This second involute is the chamfer.

The real cost of this chamfer is not measured in dollars. The unit cost is actually thousandths of an inch in length of the line of action, or fraction of a tooth in the involute contact ratio. This chamfer is badly needed by production, but is not too popular with the gear designer. To him, it means trying to recover the lost involute contact ratio. Figure 6 shows what this apparently insignificant item can do to the line of action.

This gear set, with maximum outer diameters, has a 1.534 involute contact ratio. In granting a .006 in. working tolerance on the outer diameters of both gears, we sacrifice .052 contact ratio. This loss is small when compared to the cost of the maximum .010 in. tip chamfer which brings the minimum contact ratio down to 1.308. ▲▲▲

This article was abstracted from a paper presented at the SAE Summer Meeting, Chicago.

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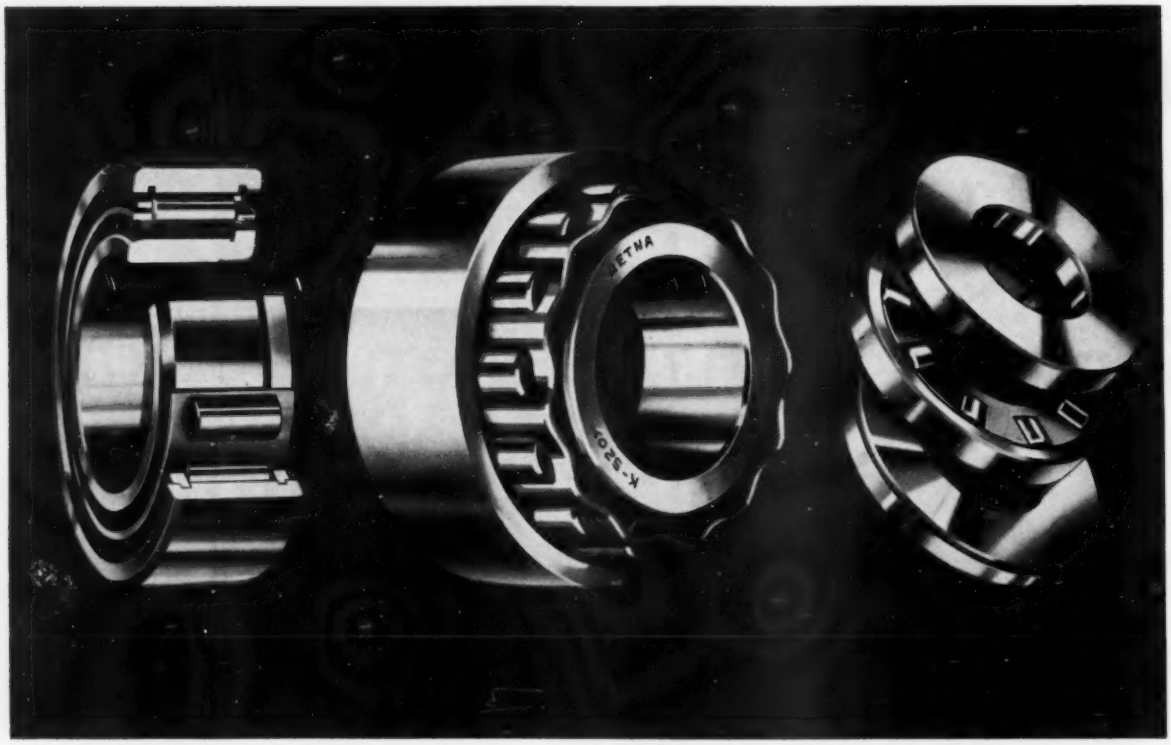

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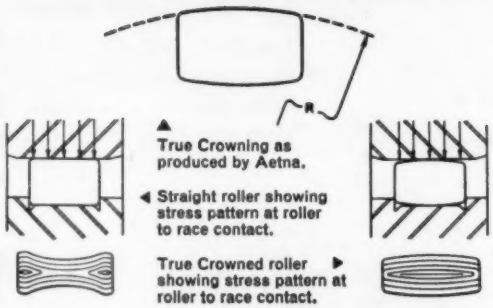

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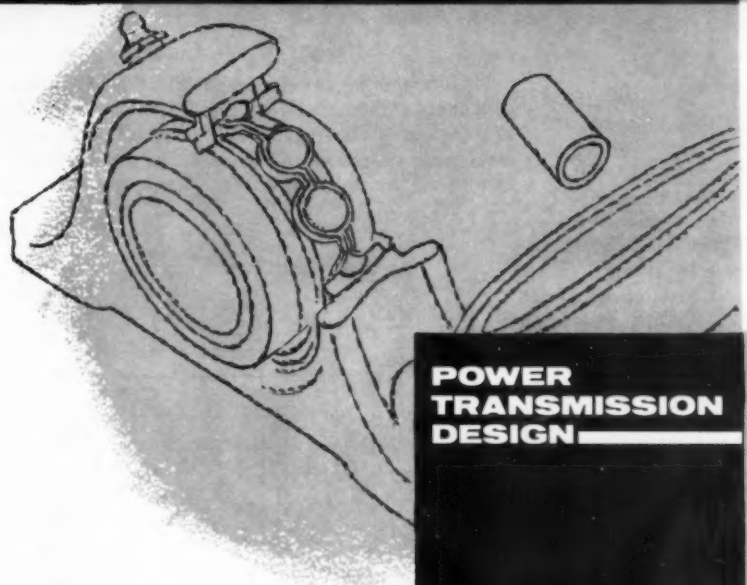

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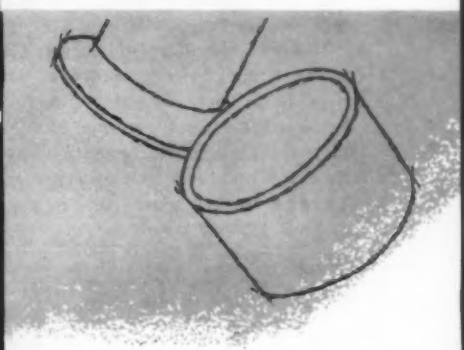
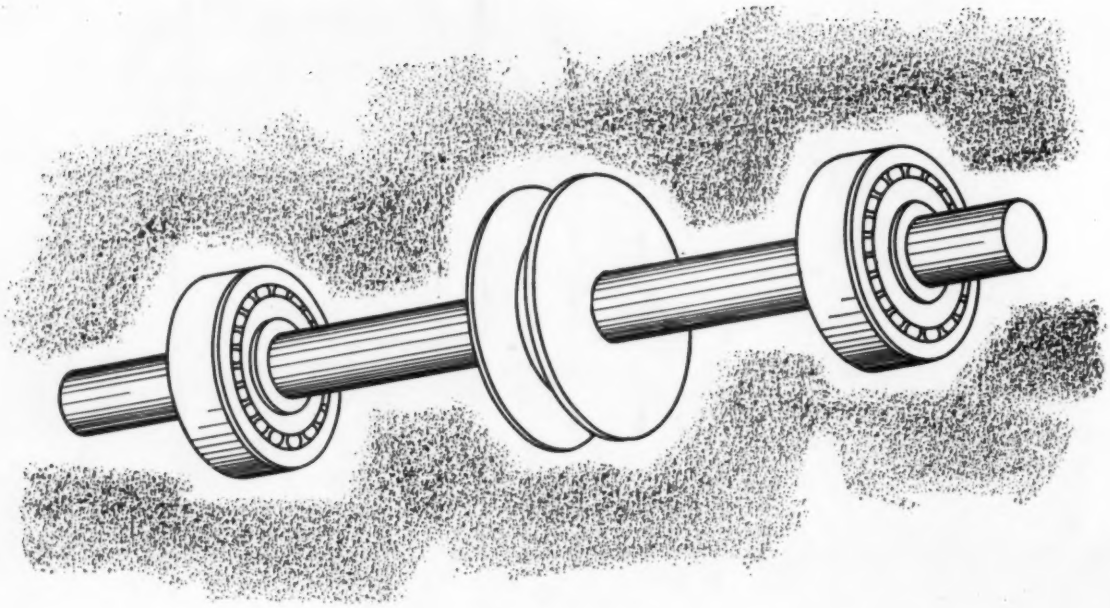




Determining bearing loads

. . . due to power transmission with

- **Bevel gears**
- **Hypoid gears**
- **Worm gears**

IN A PREVIOUS article[1], methods for calculating bearing loads due to power transmission with belts and pulleys, chain and sprockets, spur gears, and helical gears were discussed. In addition to the formulas and methods for finding thrust, tangential load (load equal to the force component of the transmitted torque), and separating force, methods for resolving tangential load and separating force into a single radial load were discussed.

This article will cover calculation of the forces resulting from power transmission with straight bevel, spiral bevel, hypoid, and worm gear sets. Resolution of tangential and separating forces will also be considered. Although all calculations assume that axes of the shafts on which mating gears are mounted are in the same vertical plane, this is not necessarily so in practice. However, calculations are the same regardless of the plane in which the shafts lie, as long as weight of the shafts and gears is neglected.

Straight Bevel Gears

There are three force components to be considered with gears of this type. They are: (1) tangential force, (2) separating force, and (3) thrust. Directions of these loads are shown in Figure 1. Tangential force is found from

$$P = \frac{T}{r} \qquad \text{.....(1)}$$

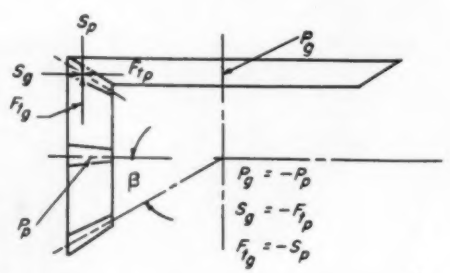


FIGURE 1. Forces on a straight bevel gear set due to power transmission.

[1] *"Determining Bearing Loads Due to Power Transmission," page 48, May, 1960, PTD.*

where P = tangential force, lb,
T = torque, lb-in.
r = pitch radius of driving gear, in.

This force is the same in magnitude for both gears, but opposite in direction.

With P known, separating force can be found from

$$S = P \tan\alpha \cos\beta \quad \text{.....(2)}$$

and thrust is given by

$$F_t = P \tan\alpha \sin\beta \quad \text{.....(3)}$$

where F_t = thrust, lb
α = pressure angle, deg
β = pitch cone angle/2, deg

These forces result in equal and opposite forces on the other member of the gear pair. But, due to geometry, separating force on one gear is thrust on the other, and the thrust on one becomes the separating force on the other. In the very special case of miter gears (β = 45 deg) separating force equals thrust.

In resolving these three forces to find total radial load on the shaft bearings, there is a component due to thrust which must be considered as well as the separating and tangential components. This will be demonstrated by an example.

Example: Forces acting on the pinion and pinion shaft and the resulting bearing loads for the straight bevel gear set shown in Figure 2 will be calculated. First step is to find tangential force from Equation 1 and the given conditions.

$$P = \frac{T}{r} = \frac{75}{3} = 25 \text{ lb}$$

Then, from Equations 2 and 3 separating force and thrust can be found.

$$S = P \tan\alpha \cos\beta = 25\ (.364)\ (.866) = 10.5 \text{ lb}$$

$$F_t = P \tan\alpha \sin\beta = 25\ (.364)\ (.500) = 4.6 \text{ lb}$$

With these values, reaction at Bearing 1, which is equal in magnitude and opposite in direction to the bearing load can be found by summing moments about Bearing 2. Since the forces act in both vertical and horizontal planes, it is necessary to find the reactions in both planes and then sum them. The only force producing horizontal load on the pinion is tangential.

Nomenclature

E = efficiency
F_t = thrust, lb
f = coefficient of friction
g = subscript denoting gear
h = subscript denoting horizontal
P = tangential force, lb
p = subscript denoting pinion
R = radial bearing reaction, lb
ΣR = total radial bearing reaction, lb
r = radius, in.
S = separating force, lb
T = torque, lb-in.
v = subscript denoting vertical
w = subscript denoting worm
α = gear tooth pressure angle
β = pitch cone angle/2
γ = spiral angle
θ = worm helix angle

Reaction at bearing 1 is given by

$$R_1 \times 5 + P_p \times 2 = 0,\ R_1 = \frac{-(25 \times 2)}{5} = -10 \text{ lb}$$

The minus sign shows that bearing reaction tends to produce rotation in the opposite sense to that which the tangential force tends to produce. Therefore, horizontal reaction at bearing 1 is in the same direction as the tangential force.

Horizontal reaction at Bearing 2 can be found by summing forces in the horizontal plane. Thus,

$$R_1 + R_2 + P = 0,\ 10 + 25 = -R_2 = 35$$

The minus sign here shows that R_2 is opposite in direction to both tangential force and the reaction at bearing 1.

Vertical components of the radial load can be found

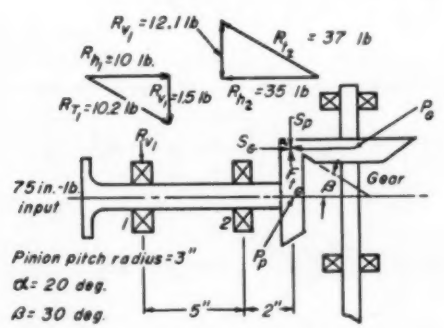


FIGURE 2. Diagrams of the bevel gear set for which loads are calculated in this article.

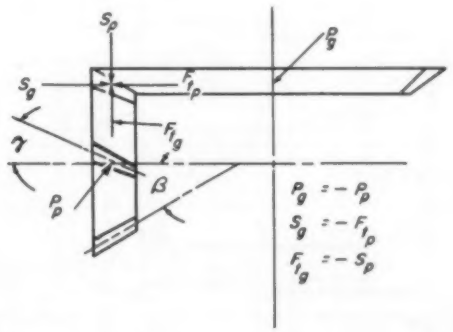
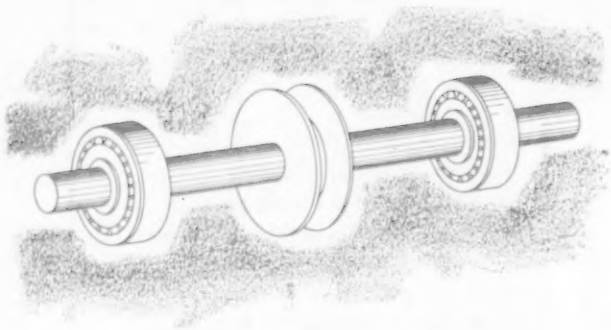


FIGURE 3. Forces on a spiral bevel gear set due to power transmission.



DETERMINING BEARING LOADS *continued*

by summing moments in the vertical plane. These are: the separating force times its moment arm and thrust times its moment arm. Moment arm for the thrust is the pitch radius of the pinion. Thus, summing vertical moments about Bearing 2,

$$S_p \times 2 + R_{v1} \times 5 - (F_{tp} \times 3) = 0,$$

$$R_{v1} = \frac{4.6 \times 3 - (10.5 \times 2)}{5} = -1.6 \text{ lb}$$

The minus sign, in this instance, indicates that the reaction tends to produce counterclockwise rotation about Bearing 2, since the clockwise moment of the separating force was assumed positive.

Now, by summing forces in the vertical plane, reaction at Bearing 2 can be found.

$R_{v1} + R_{v2} + S_p = 0$, $R_{v2} = 1.6 + 10.5 = 12.1$ lb.

In this case upward forces are assumed to be positive and downward forces negative. Therefore, the reaction at Bearing 2 is upward.

Loads on the bearings are equal in magnitude to the reactions but opposite in direction. Total load and direction is found by vectorially summing vertical and horizontal loads. Total load at Bearing 1 is given by

$$\Sigma R_1 = \sqrt{10^2 + 1.5^2} = 10.2$$

and total load at Bearing 2 is

$$\Sigma R_2 = \sqrt{12.1^2 + 35^2} = 37 \text{ lb}$$

Spiral Bevel Gears

Calculating loads for spiral bevel gearing is much like the procedure used with plain bevel gears. Loads are the same basically as for straight bevel gears, Figure 3. However, the spiral does add a little complication. Whether the spiral is right or left hand and the direction of rotation must be considered. Since thrust load on the pinion is equal to the separating force on the gear, and thrust load on the gear equals separating force on the pinion, only the formulas for thrust on pinion and gear will be given here.

To determine these thrusts, tangential force must first be found. Again, Equation 1 supplies this value. Values of thrust are then found, depending upon direction of rotation of the pinion and hand of the spiral from either

$$F_{tp} = P\left(\frac{\tan\alpha \sin\beta}{\cos\gamma} - \tan\gamma \cos\beta\right) \quad \text{.....(4)}$$

$$F_{tg} = P\left(\frac{\tan\alpha \cos\beta}{\cos\gamma} + \tan\gamma \sin\beta\right) \quad \text{.....(5)}$$

or

$$F_{tp} = P\left(\frac{\tan\alpha \sin\beta}{\cos\gamma} + \tan\gamma \cos\beta\right) \quad \text{.....(6)}$$

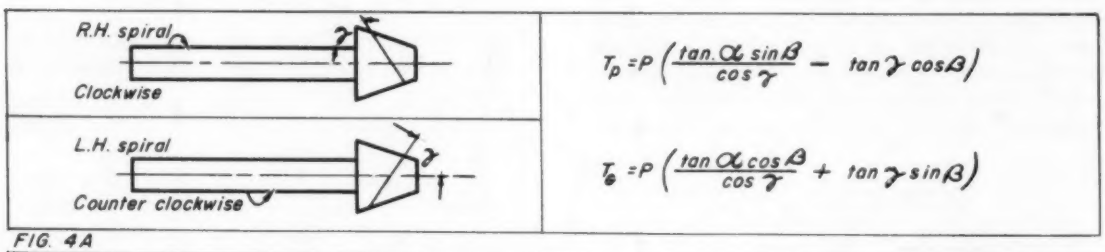


FIG. 4A

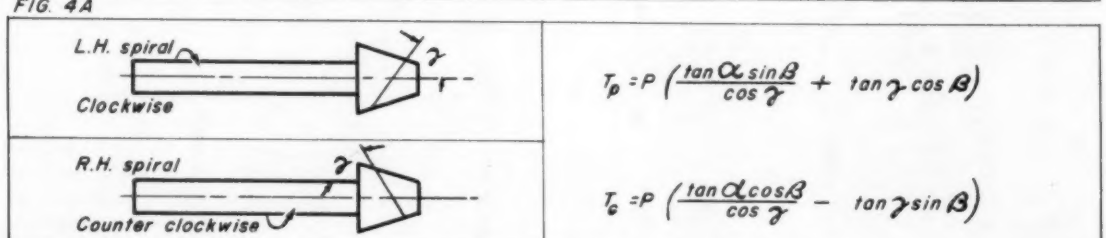


FIG. 4B

FIGURE 4. Possible combinations of helix angle and pinion rotation in spiral bevel and hypoid gear sets. Equations 4 and 5 are used for combinations at a. Equations 6 and 7 are used with combinations at b.

$$F_{tg} = P\left(\frac{\tan\alpha\cos\beta}{\cos\gamma} - \tan\gamma\sin\beta\right) \quad \text{.....(7)}$$

where α = tooth pressure angle
β = pinion pitch cone angle/2
γ = spiral angle

Equations 4 and 5 are used when: (1) Rotation of the pinion shaft is clockwise viewed from the big end of the pinion and the pinion spiral is right hand, or (2) Rotation of the pinion shaft is counterclockwise viewed from the big end of the pinion and the pinion spiral is left hand, see Figure 4a.

Equations 5 and 6 are used when: (1) Rotation of the pinion shaft is clockwise viewed from the big end and the pinion spiral is left hand, or (2) Rotation of the pinion shaft is counterclockwise viewed from the big end and the spiral is right hand, see Figure 4b.

With the values of tangential force, thrust, and separating force determined, vertical, horizontal and total loads on the bearings are found in the same way as in the example for straight bevel gears.

Hypoid Gears

In a hypoid gear set, Figure 5, the axes of the pinion and gear do not intersect. The effect of this offset or pinion drop, h, on calculations is to change the effective radius of the gear, and to introduce a moment acting on the gear due to separating force (pinion thrust) which affects the vertical radial load on the gear shaft bearings. Moment arm in this instance is the offset or drop.

With this exception all formulas and calculations are exactly the same as for the spiral bevel gear set. The following example shows this effect.

Example: Forces on Bearings 1 and 2 of the hypoid gear set shown in Figure 5 will be calculated. First, from Equation 1, tangential force is found.

$$P = \frac{T}{r} = \frac{250}{2} = 125 \text{ in.-lb}$$

Then from Equations 5 and 6, because a left-hand spiral with clockwise rotation of the pinion is assumed,

$$F_{tp} = 125\left(\frac{.364 \times .309}{.966} + .268 \times .951\right) = 47 \text{ lb}$$

$$F_{tg} = 125\left(\frac{.364 \times .951}{.966} - .364 \times .309\right) = 31 \text{ lb}$$

The forces contributing to vertical radial load on the bearings are P_g which equals P_p, and the separating force, $S_g = -F_{tp}$, which acts at distance h below the shaft. So, by summing moments about Bearing 1, vertical radial reaction at Bearing 2 is

$$R_{2v} \times 12 + P_g \times 6 - F_{tg} \times 2 = 0,$$

$$R_{2v} = \frac{31 \times 2 - 125 \times 6}{12} = -57.3 \text{ lb}$$

The minus sign indicates that reaction at Bearing 2 would produce counterclockwise rotation about Bearing 1. Therefore, the reaction is upward. The term $-F_{tg} \times 2$ here is introduced by the pinion offset.

Similarly,

$$R_{1v} \times 12 - P_g \times 6 - F_{tg} \times 2 = 0,$$

$$R_{1v} = \frac{125 \times 6 + 31 \times 2}{12} = 67.7 \text{ lb}$$

The plus sign indicates that R_{1v} would produce clockwise rotation about Bearing 2. Therefore, R_{1v} acts upward.

Forces contributing to horizontal radial load on the bearings are gear thrust and separating force. Gear thrust acts at an effective radius, r_e, from the center

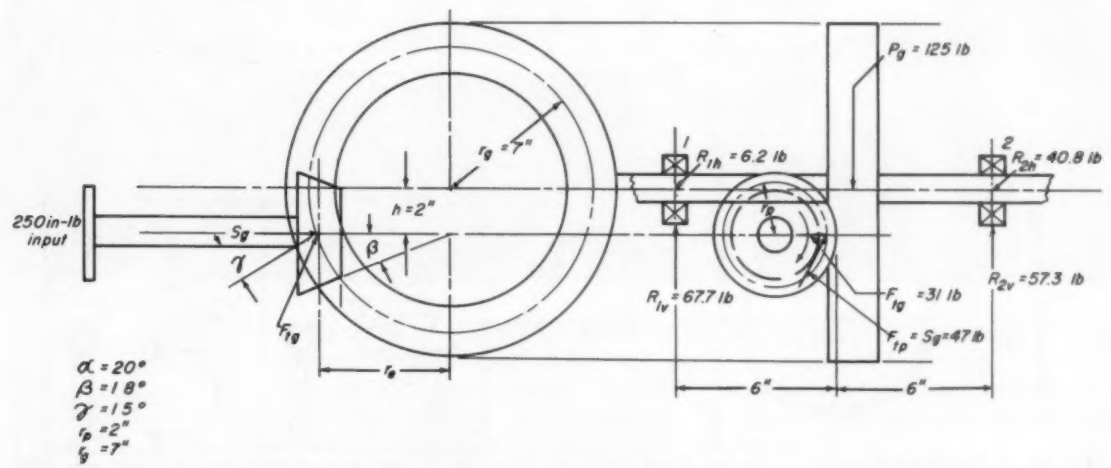
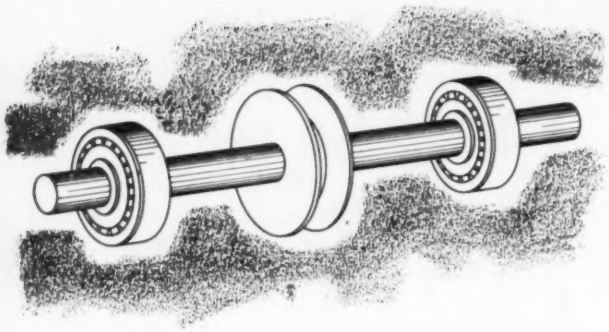


FIGURE 5. Diagram of the hypoid gear set for which bearing loads are calculated in this article.



DETERMINING BEARING LOADS *continued*

of the gear. This is the projection in the horizontal plane of the mean gear radius and is found from

$$r_e = \sqrt{r_g^2 - h^2} \quad \text{.....(8)}$$

In this case,

$$r_e = \sqrt{7^2 - 2^2} = 6.7 \text{ in.}$$

Using this value, bearing reactions in the horizontal plane can be found. Summing moments about Bearing 2 gives

$$R_{1h} \times 12 + S_g \times 6 - F_{tg} \times 6.7 = 0,$$

$$R_{1h} = \frac{F_{tg} \times 6.7 - S_g \times 6}{12} = \frac{31 \times 6.7 - 47 \times 6}{12}$$

$$R_{1h} = -6.2 \text{ lb}$$

The minus sign indicates that horizontal reaction at Bearing one tends to produce counterclockwise rotation about Bearing 2 as viewed from above. Therefore, this reaction is opposite in direction to S_g. In similar manner, horizontal reaction at Bearing 2 is found by summing moments about Bearing 2. Again, thrust acting at the effective gear radius contributes.

$$R_{2h} \times 12 - S_g \times 6 - F_{tg} \times 6.7 = 0,$$

$$R_{2h} = \frac{47 \times 6 + 31 \times 6.7}{12} = 40.8 \text{ lb}$$

These values summed vectorially give total reaction.

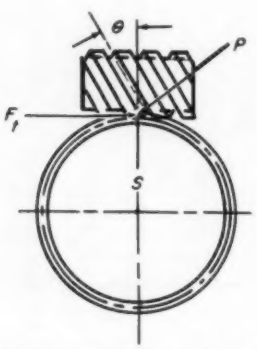


FIGURE 6. Forces on a worm set due to power transmission.

$$\Sigma R_1 = \sqrt{6.2^2 + 67.7^2} = 68 \text{ lb}$$

$$\Sigma R_2 = \sqrt{57.3^2 + 40.8^2} = 70 \text{ lb}$$

Worm Gears

Calculating bearing loads for worm gearing is relatively straightforward. Forces to be considered are all at right angles to each other and act at point of contact between worm and wheel, Figure 6. Thrust applied at the pitch radius contributes to radial loading on both worm and gear shafts and must be considered when calculating these loads. Direction of thrust for different combinations of rotation and hand of the helix are shown in Figure 7.

Forces on the worm, which is the driving member, are: tangential (computed from Equation 1); thrust, found from

$$F_{tw} = P_w \cot \theta \quad \text{.....(9)}$$

and separating force, given by

$$S_w = \frac{P_w \tan \alpha}{\sin \theta} \quad \text{.....(10)}$$

where α = normal pressure angle
θ = worm helix angle

Forces on the gear are: tangential, thrust, and separating, found successively from the following three equations.

$$P_g = -T_{tw} \times E \quad \text{.....(11)}$$

$$F_{tg} = -P_w \quad \text{.....(12)}$$

$$S_g = -S_w \quad \text{.....(13)}$$

where E = efficiency of worm and gear

Efficiency is calculated from

$$E = \frac{\tan \theta (1 - f \tan \theta)}{f + \tan \theta} \quad \text{.....(14)}$$

where f = coefficient of friction

Since the effect of efficiency in Equation 11 is to reduce the value of P_g, and efficiency of a well-designed properly lubricated worm gear set is quiet high, it may be ignored in many calculations. However, with extremely high ratios and coefficients of friction, the reduction in load may permit smaller bearings to be used on the gear shaft. ▲▲▲

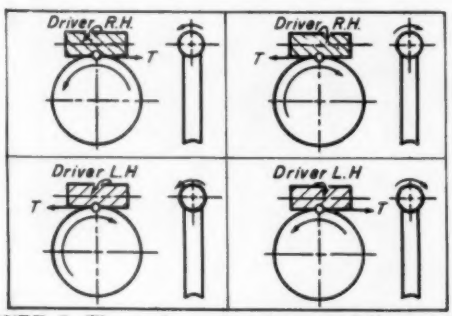


FIGURE 7. Thrust force direction for different worm gear sets.

GETTING YOUR SHARE?

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Every issue of POWER TRANSMISSION DESIGN offers a gold mine of design product, application and industry information. Product facts, catalogs, data books, manuals: the latest facts for your engineering and purchasing files are yours for the asking. The easy way to ask is to use one of the Reader Service Cards bound into this issue.

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NEW PRODUCTS

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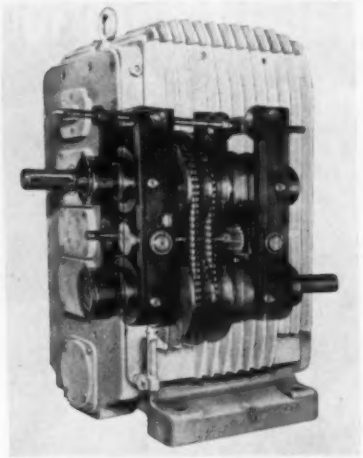
Variable speed drive

In this drive twin strands of single roller chain operate between a pair of facing wheels having a floating center disc. Effective diameter of the



wheel faces can be altered during operation to change the ratio and output shaft speed, giving stepless adjustment between maximum and minimum settings. Called Type RS-33, drives are for capacities up to 50 hp and ratios to 5.5:1. Five types are available, including models with input and output gears and integral foot-type motors. Drives of 3.8:1 and less can be directly coupled to a 1750 rpm motor.

Link-Belt Co., Chicago, Ill.

Circle No. 200 on Reader Service Card

Midget bearing

For shaft sizes of ¼ in., 5/16, ⅜ and 7/16 in., bearing is permanently lubricated and has a sintered bronze bushing. Other design points are easy installation in the end bell housing and elimination of oil lines, reservoirs etc. Supplied to standard industry tolerances.

Randall Graphite Bearings, Inc., Lima, Ohio.

Circle No. 201 on Reader Service Card

Lubricant container

To keep dirt out of the grease and grease off of your hands, 10 oz. plastic jars of Molykote G lubricant have an applicator brush attached to the cap. A tube in the center of the jar serves as a storage well and is sealed against the grease by a fiber washer. Jar itself is oil-resistant and sealed by a synthetic rubber washer.

Alpha-Molykote Corp., Stamford, Conn.

Circle No. 202 on Reader Service Card

Instrument flexible couplings

Two types are available; Type MPC-1 consists of two flanged aluminum hubs and nylon or stainless steel discs with V-grooves that are displaced 90° with each other. These discs are fastened with stainless steel springs loading the ball pivots against V-grooves. Type MPC-2 has two cylindrical aluminum hubs, each with two ball pivots attached. Hubs are attached to a pair of flexible phosphor bronze discs which hold and load the ball pivots. Overall dimensions of MPC-1 are ⅞ x ⅞ in.; MPC-2 are ¾ x ½ in.

Technology Instrument Corp., Acton, Mass.

Circle No. 203 on Reader Service Card

Precision spur gears

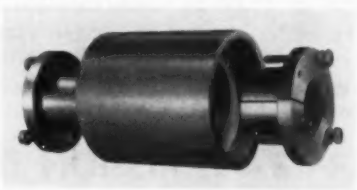
Twenty-eight varieties of Precision 2 and 3 spur gears can be had from stock. Made of passivated stainless steel or anodized aluminum, the Precision 3 gears come in pitches of 48, 64, 72, 96, 120, and 200, all in 20° pressure angles. This is said to be the first time that Precision 3 gears are available from stock.

PIC Design Corp., East Rockaway, N. Y.

Circle No. 204 on Reader Service Card

Rigid coupling

Known as the Sure-Grip No. 44, this coupling comes in five sizes with



a shaft diameter range from ½ to 5-7/16 in. Shafts are clamped by interchangeable tapered bushings so that no press or shrink fits are necessary. The precision-machined taper lines up the two shafts automatically as the proper torque is applied.

T. B. Wood's Sons Co., Chambersburg, Pa.

Circle No. 205 on Reader Service Card

Fan-cooled reducers

A line of fan-cooled worm gear reducers uses the involute helicoid form of tooth for high load carrying capacity and quiet operation. Other de-

sign features include internal cooling channels formed by ribbing on the housing and positive lubrication of gears and bearings in either direction of rotation. The line covers 12 sizes with center distances from ⅛ in. to 8 in. and input capacities from .01 to 66 hp. Both adaptable and fixed base models.

Foote Bros Gear & Machine Corp., Chicago, Ill.

Circle No. 206 on Reader Service Card

Loader transmission

A new heavy-duty version of a front-end loader transmission is designed to handle 350 ft-lb of engine torque, while providing increased hydraulic horsepower for bucket operation. The three-element torque converter has a stall ratio of 3.7:1 and gives an overall engine torque multiplication of 29.6. Ratios for loader operation are 8:1 in low, 2.9:1 in intermediate, and 1:1 in high. The transfer gear ratio is .659:1. Known as the CRT-3531, transmission weighs from 1170 to 1260 lbs, depending upon options used.

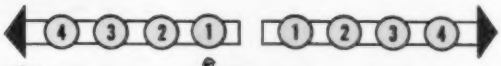
Allison Div., General Motors Corp., Indianapolis, Ind.

Circle No. 207 on Reader Service Card

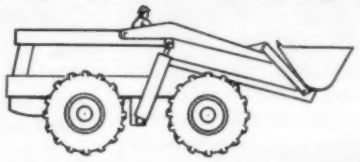
only the HYDRA-DRIVES® BDB

OFFERS ALL THESE MAJOR ADVANTAGES

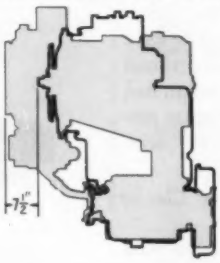
IN FULL-POWER SHIFT TRANSMISSIONS for equipment up to 175 h.p.

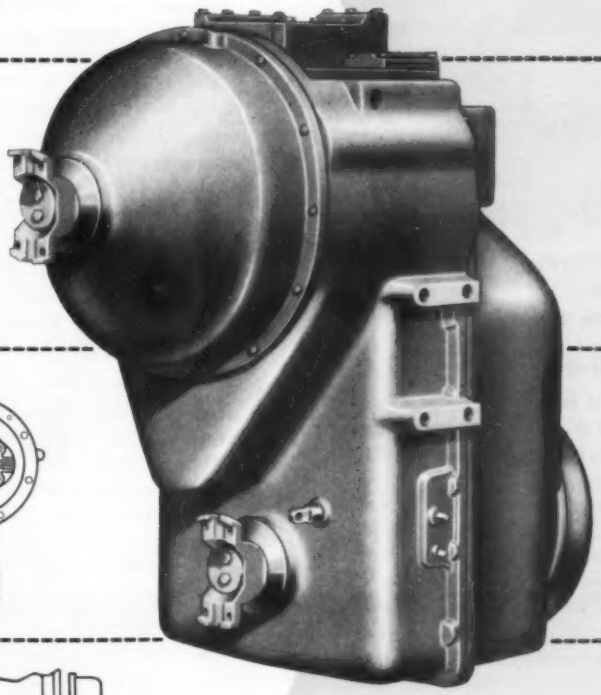


1. **4 speeds forward and reverse.** All power shifted! Provides maximum horsepower to load under all load conditions.

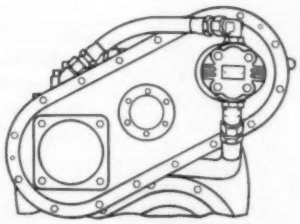


2. **Integral design.** Torque converter, transmission, oil passages, valving and oil sump are in *one* compact housing—7½" shorter than comparable models.

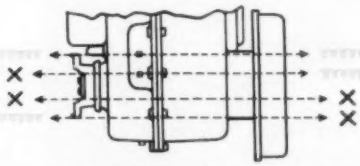




3. **Triple pump drives** – Allow implement and steering booster pumps to be installed close to the oil reservoir. Installation and maintenance costs are reduced. Single pump drive is also available.



4. **Full disconnect** provides four combinations of split drive . . . from torque on both shafts, to both shafts in disconnect.



DESIGNED FOR SPECIALIZED EQUIPMENT

Rockwell-Standard's new model Hydra-Drives Full Power Shift Transmission is designed for specialized equipment, such as front end loaders, fork trucks, scrapers, crane carriers, rubber tire tractors and military vehicles.

The Hydra-Drives BDB offers easier servicing and maintenance. There are fewer moving parts and bearings. The simple, rugged countershaft design and spur gears simplify maintenance.

A larger CBD Transmission is also available for equipment up to 250 H.P.

Another Product of... **ROCKWELL-STANDARD CORPORATION**

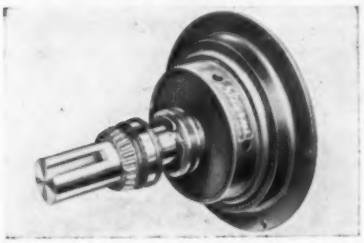
ROCKWELL R STANDARD

Transmission and Axle Division, Detroit 32, Michigan

Circle No. 22 on Reader Service Card

Electro magnetic disc clutch

An addition to a line of multiple disc clutches has the friction elements placed on the outside diameter of the magnet body. Result is



a longer torque arm for a given size unit and a comparatively greater friction area. Friction discs for 2, 4, and 6 surface models can be adjusted to compensate for lining wear. Driven member or clutch cage is flanged for attachment to driven mechanisms or can be adapted to through shaft drives with ball bearings or bronzed bush mounting. Sizes are 7, 9, 13 and 15 in. diameters with torque ratings up to 4000 lb-ft.

Stearns Electric Corp., Milwaukee, Wis.

Circle No. 208 on Reader Service Card

Self-wicking lubricant

This material is a combination of oil and minutely particled cellulose fibers which resembles grease but is more than 85% fine lubricating oil. Called Permawick, it can release and reabsorb oil to maintain the bearing oil film. Used in sleeve bearings, it occupies less than half the volume of felt wick and oil dam reservoirs and can be injected automatically during bearing assembly. Bearings containing this oil and wick combination have performed well at continuous temperatures to 200 F and under high loading. Pour point is —25 F. Also recommended for sintered bearings.

Permawick Co., Detroit, Mich.

Circle No. 209 on Reader Service Card

Angular motion transducer

Transducer is the Metrisite type which uses a three-legged magnetic core with a coil around each leg. Identical secondary coils are connected in series opposition. The center leg has an air gap in which a lightweight, non-magnetic armature moves. When an ac input energizes the center primary coil, the magnetic

field in both loops of the core induces a voltage in the secondary coils. With the armature centered, the magnetic fields are symmetrical and induced voltages in the secondary coils are equally opposed. Output is zero. Slightest movement of the armature off center produces an imbalance of the two fields resulting in an electrical output signal equal to the difference in voltage between secondary coils. Output is directly proportional to armature movement. Designated Type 34A, unit measures angular motions up to plus or minus 40° with better than 0.25% linearity.

Brush Instruments, Div. of Clevite Corp., Cleveland, Ohio.

Circle No. 210 on Reader Service Card

Motorized speed reducer

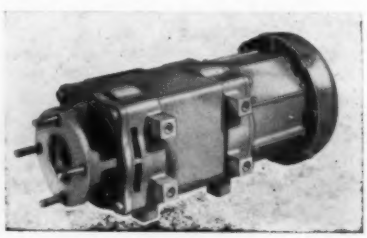
For applications that need a light-duty compact motorized reducer, the MW109 Ratiomotor is a standard stock model that offers output speeds from 1.9 to 70 rpm. Reducer is worm-geared, parallel drive model. Motor comes with ratings of 1/20 hp or .035 hp.

Boston Gear Works, Quincy, Mass.

Circle No. 211 on Reader Service Card

Lightweight dc motor

Originally designed to drive a missile pump, motor features a flame quenching device that permits greater heat dissipation and a higher output rating for a given motor frame size. Construction details include integral cooling fan, precision ground



ball bearings, steel insert bearing liners, radio noise filter, square frame construction for reduced size, and explosion proof construction. Performance data gives 4 hp at 8500 rpm continuous duty, 6 hp at 7300 rpm intermittent duty for a 26.6 input voltage. An electro-magnetic clutch-brake and reduction gearing are optional. Overall length is 10.94 in., width is 6 in.

Hoover Electric Co., Columbus, Ohio.

Circle No. 212 on Reader Service Card

Contact seal

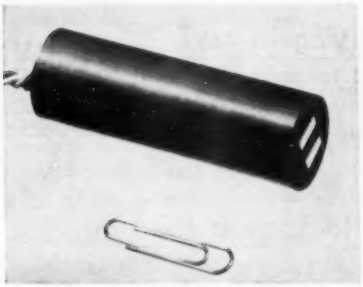
Seal is for use with the "L" Series bearing units. It consists of a three part assembly that presses on the ID of the outer race. The inner flinger rides in close running clearance with the OD of the inner race. The outer flinger is a solid circular ring. These two flingers hold in position a Buna N coated fabric washer that has an interference fit on the OD of the inner race. The L and SL bearings and L bearing units are available in the following shaft sizes: ¾ in., ⅞, 15/16, 1, 1-⅛, 1-3/16, 1-¼ (special), 1-¼ (standard), 1-5/16, 1-⅜ and 1-7/16 in.

Sealmaster Bearing Div., Stephens-Adamson Mfg. Co., Aurora, Ill.

Circle No. 213 on Reader Service Card

Low-cost proximity switch

Design of the switch is based on a spring-loaded beam pivoted against a magnetic force. Differential between on and off position is approximately .008 in. Coil spring maintains high pressure so that beam cannot dwell between on and off. Repeatability is within .001 in. The switch may be actuated by objects moving either axially or tangentially and may also be keyed to a selected contour or oriented magnet for switching across



a larger gap. Contacts are rated at 6 amps at 110 v, resistive load and 3 amps at 220 v. for nominal life, thus requiring no separate power supply. Dimensions are 13/16 in. OD and 2½ in. long.

Tann Controls Co., Div. of Tann Corp., Detroit, Mich.

Circle No. 214 on Reader Service Card

Control synchros

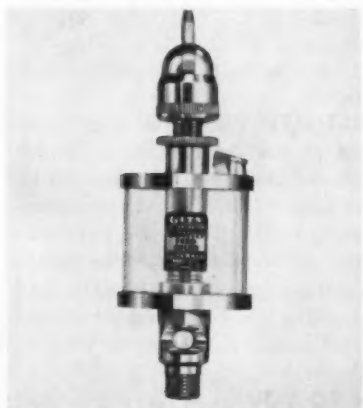
Precision 3-minute control synchros engineered to MIL-S-2335, 12472, 16892, 20708A are in regular production. Also available are synchro transformers, transmitters and differential transmitters in all sizes from 11 through 23, each with maximum electrical error of plus or minus 3 minutes.

Vernitron Corp., Long Island, N. Y.

Circle No. 215 on Reader Service Card

Gravity-feed oiler

A low cost gravity-feed oiler has a needle valve adjustment that can be locked by a knurled ring nut once the flow rate has been fixed. Other



features are a toggle lever shut-off and a sight feed window to check the oil delivery rate. Comes with both glass and unbreakable plastic reservoirs.

Gits Bros Mfg. Co., Chicago, Ill.

Circle No. 216 on Reader Service Card

• **What is this writer trying to say?** "In instances of mobile applications where fluid temperature due to intermittent operation and continued exposure remains low, a high-viscosity-index, low-pour-point fluid would be mandatory for reliable operation."

• **What he wants you to know is this:** "Machines used outdoors in winter need oil that isn't affected by the cold." Well if that's what he meant, why didn't he say so? Good question. The reason you have to hack your way through doubletalk in some technical and business magazines is that writing things clearly and simply is hard work—a lot harder and much more expensive than putting them down in technicalese (the special language of engineers and longhairs.) The odd part of this problem is that even the longhairs who *write* technicalese don't like to *read* it. That is why the articles in this magazine have been distilled.

Distilled Writing gives you facts without fluff

Our research department told us that we—like other publishers—were taking too much of our space and your time to get the facts across. That's where Distilled Writing comes in.

• **WHAT'S DISTILLED WRITING?** It's copy with the extra words squeezed out. It gives each article exactly as much space as it really needs . . . not one line more! This isn't a digesting process: all the facts are still there, but the verbiage is gone. For example, we take this kind of writing . . . and distill it to this:

eliminate unwanted vegetation	kill weeds
It is used to rupture missile frames in flight to initiate aerodynamic distintegration.	It makes missile frames explode in flight.
formation of iron oxide binding the two surfaces	rusted together

Distilled Writing is the registered service mark of The Industrial Publishing Corporation

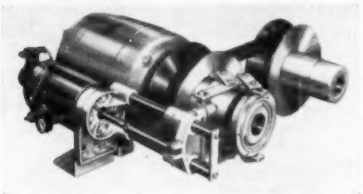
• **HOW WE DEVELOPED DISTILLED WRITING.** First we hired Dr. David Kinsler to head up our distilling on a fulltime basis. He works with all our editorial staffs, teaching sharp, concise writing. Second, we retained Robert Gunning, the top authority on readable writing, as our consultant. Third, we put every line of copy—whether staff-written or by an expert in the field—through the distilling process before it goes to the printer. Our whole editorial effort is aimed at telling the story brightly, clearly, briefly.

• **WHAT DOES THIS MEAN TO YOU?** The story that used to take four pages is now told in two or three. Shorter articles mean more of them in each issue. You get more information for your reading time and you don't have to dig it out. It takes more work for us to do it, but Distilled Writing pays off in the time it saves for our busy readers.

POWER TRANSMISSION DESIGN ● **812 HURON ROAD, CLEVELAND 15, OHIO**

Pneumatic pulley regulator

Regulator operates from process instruments in the 3 to 15 psi signal range, to obtain speeds which are varied, maintained or repeated with the signal pattern. Speed flexibility



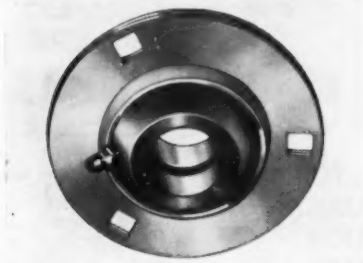
makes possible continuous process control. Available in ratings to 25 hp in speed ranges to 10:1.

Lewellen Mfg. Co., Columbus, Ind.

Circle No. 217 on Reader Service Card

Center flange bearings

The new series covers three basic sizes of heavy duty self-aligning bearings. Ball units can be either pressed



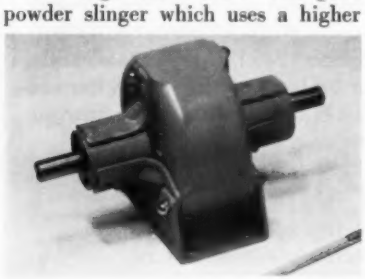
steel or cast iron sleeve type. Mountings are made from 13 gauge steel and are interchangeable with ball bearing flange units. Bolt holes can be varied in size, shape and number to meet special requirements. All standard shaft sizes are available from ½ in. to 1 ¾ in., with a choice of oil or grease lubrication.

Triangle Mfg. Co., Oshkosh, Wis.

Circle No. 218 on Reader Service Card

Magnetic particle clutch

An improved version of the Model 622-A Magneclutch has a redesigned powder slinger which uses a higher



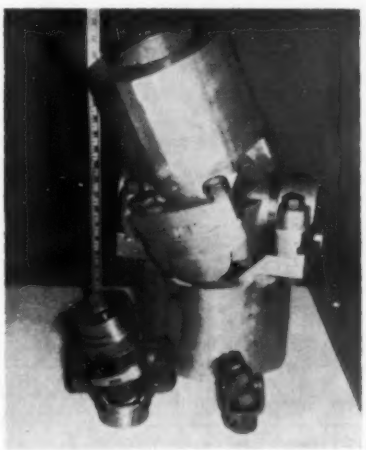
percentage of the powder and gives more stable torque characteristics. Higher grade bearings and powder seals should insure longer life under continuous duty. Operating data gives a rated torque of 10 lb-ft, non-excited drag torque of 0.05 lb-ft. Coil power at 63 vdc, 0.20 amp., is 18.0 watts. Maximum recommended operating speed is 7000 rpm. The new clutch weighs a third less and costs a third less than former models.

Vickers Inc., Electric Products Div., St. Louis, Mo.

Circle No. 219 on Reader Service Card

Big universal joint

The largest universal joint ever to come off the company lines, it's called the Blood Brothers Model 150WB.



Maximum torque capacity using a safety factor of 10 to 1 is 162,000 in.-lb, with a breaking factor of 600,000 in.-lb. Swing diameter is 13½ in. Joint can be disassembled by removing four bolts. Available as a plain joint, double joint, or assembly.

Rockwell-Standard Corp., Universal Joint Div., Allegan, Mich.

Circle No. 220 on Reader Service Card

Plastic bushing

A rapid-locking plastic bushing is a simplified device for assembly of parts which rotate, pivot, or rock. It's made in one piece and, as it is inserted into the moving part, it automatically snaps onto the axle. There's no need for a separate holding device, as the bushing combines journal and thrust collar.

M-H Standard Corp., Jersey City, N. J.

Circle No. 221 on Reader Service Card

Tiny electric brakes, clutches

Less than 1 in. in diameter and ⅞ in. long, models RF (brake) and SF (clutch) are for equipment requiring rotary drives which cycle automatically or by remote control. An ener-

gized field transmits torque to the armature through a rotor (clutch) or through a friction face mounted directly to the field (brake). The field is always stationary, needs no slip rings or brushes to supply current. Current is 28 or 90 vdc. The armature floats axially on a separate hub and has a square drive which distributes the load evenly on large flat bearing surfaces. Unit is flange-mounted. For power drives rated up to 1.5 lb-in.

Warner Electric Brake & Clutch Co., Beloit, Wis.

Circle No. 222 on Reader Service Card

Shield material

Called Alu-Flex H. T., it is a silicone rubber with aluminum mesh. Designed to prevent radio frequency energy escaping from containers with RF emitting apparatus, it gives air and fluid sealing for temperatures from 500 to —65 F. Made in any size or shape gasket, seal, shim, ring, etc., in two thicknesses, .016 and .020 in.

Auburn Mfg. Co., Middletown, Conn.

Circle No. 223 on Reader Service Card

Teflon piston rings

Rings are made from processed carbon-filled Teflon. Thermal stability is high, with a continuous service temperature range from —420 to 500 F. For use where lubrication is impossible, such as processes involving gases or non-lubricating liquids, these rings will imbed hard particles without damage to cylinder or ring. Available in different designs, including butt joint, step joint, scarf cut, or solid design. Matched rider rings also available.

Garlock, Inc., Palmyra, N. Y.

Circle No. 224 on Reader Service Card

Winder drive

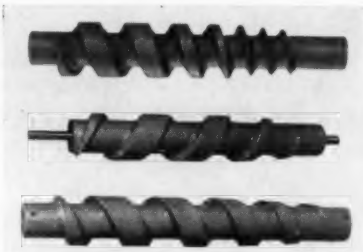
A winder for paper, plastics, textiles, rubber, wire, etc. has a drive unit that controls tension by hydraulically maintaining an internal balance of torque between the hydraulic circuit and the roll being wound. The varying torque created by roll build-up is compensated for in the hydraulic circuit. A scale shows torque.

Sealol, Inc., Providence, R. I.

Circle No. 225 on Reader Service Card

Timing screws

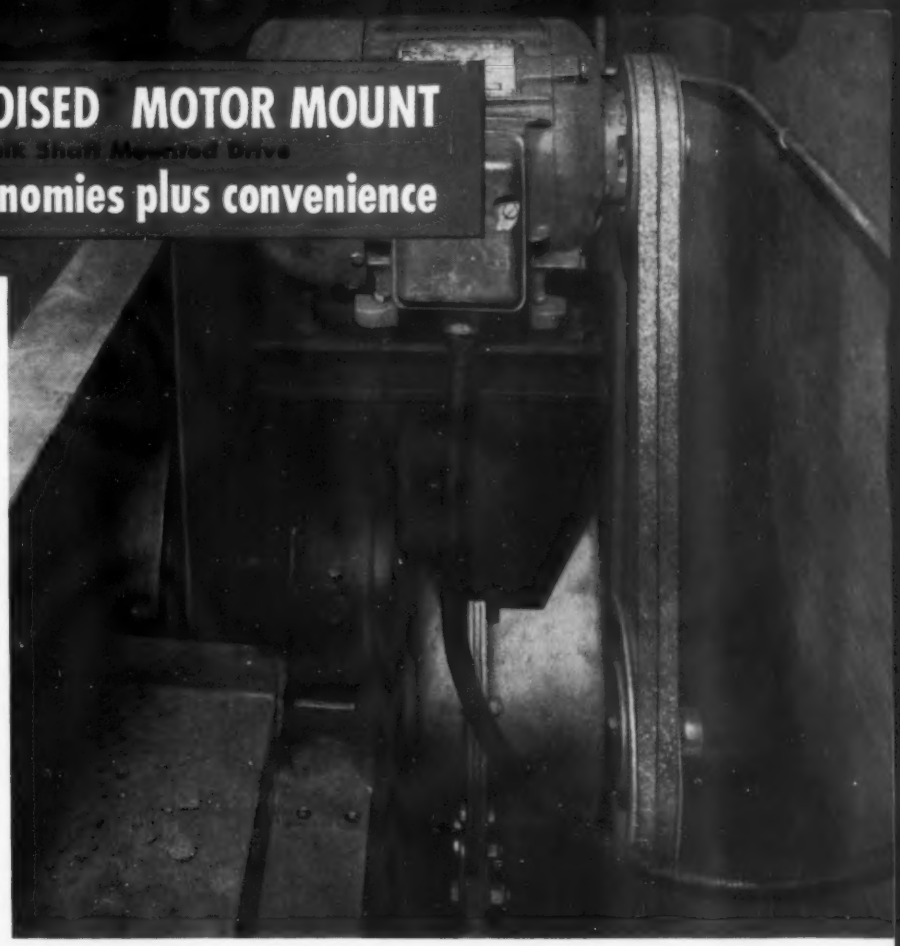
Screws are designed to pick up containers from a conveyor, move them under controlled acceleration and speed, and discharge them at required spacing. Screw form matches that of the container as well as the



NEW FALK EQUI-POISED MOTOR MOUNT

For use with the Falk Shaft Mounted Drive

gives unequaled economies plus convenience

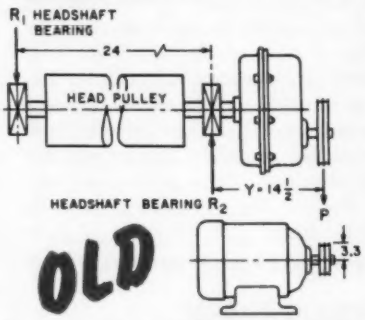


HOW A FALK EQUI-POISED MOTOR MOUNT REDUCES BEARING LOADS ON A DRIVEN MACHINE

GIVEN: Motor—15 hp, 1750 rpm, Frame 284U, Weight—320 lb.
Sheave diameters—6.6/9.4
Driven machine—belt conveyor with 24" center distance between headshaft bearings.

NOTE: Weights of 307J24 Shaft Mounted Drive, sheaves, and V-belts are eliminated from calculations because they remain constant; do not affect the comparison.

WITHOUT FALK MOTOR MOUNT



Torque at motor shaft = $\frac{63{,}025 \times 15 \text{ hp}}{1750 \text{ rpm}} = 540$ lb-in.

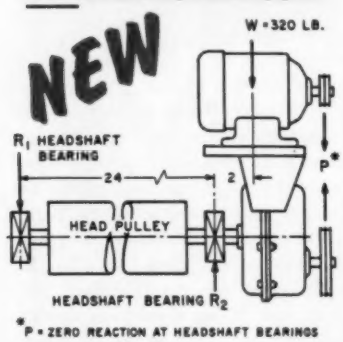
Belt pull (P) = $\frac{540 \text{ lb-in.}}{3.3''} \times 1.5$ Load Connection Factor
= 246 lb

$R_2 = \frac{246 \text{ lb} \times (24'' + 14.5'')}{24''} = 395$ lb

$R_1 = \frac{246 \text{ lb} \times 14.5''}{24''} = 149$ lb

(Check: 395 lb—149 lb=246 lb)

WITH FALK MOTOR MOUNT



*P = ZERO REACTION AT HEADSHAFT BEARINGS

V-belt pull has zero reaction on headshaft bearings. Therefore—

$R_2 = \frac{320 \text{ lb} \times (24'' + 2'')}{24''} = 347$ lb

$R_1 = \frac{320 \text{ lb} \times 2''}{24''} = 27$ lb

(Check: 347 lb—27 lb=320 lb)

Falk's new EQUI-POISED* Motor Mount is a

rigid, all-steel weldment, pre-drilled for bolting standard NEMA foot-mounted motor (1/2 to 30 hp) directly to the steel frame of Falk Shaft Mounted, Flange Mounted and Screw Conveyor Drives. With it, motor can be mounted in almost any position around perimeter of reducer.

(**Balancing of forces.*)

Substantial Savings for You

It saves engineering time required to design special motor bases and foundations...saves cost of labor and materials required to build special motor foundations...and saves on equipment costs by using a quality stock component. Further, its quick installation and easy maintenance mean added cost savings. The Motor Mount is a space saver, too. Where restricted space is a factor, ability to mount motor in any of several positions is an important convenience...For information on range of sizes, dimensions, etc., contact your Falk Representative or Distributor—or write direct for Bulletin 7100.

THE FALK CORPORATION, MILWAUKEE 1, WISCONSIN

MANUFACTURERS OF QUALITY GEAR DRIVES AND FLEXIBLE SHAFT COUPLINGS

FALK

a good name in industry

Representatives and Distributors in most principal cities

Circle No. 13 on Reader Service Card

FALK is a registered trademark

machine pitch requirements. Power is from the takeoff of the packaging machine drive to assure synchronization. They can also be used as line dividers for line synchronization.

Arthur Colton Co., Detroit, Mich.

Circle No. 226 on Reader Service Card

Universal joint coupling

A close-coupled double universal joint coupling is of all-metal construction, corrects angular and parallel misalignment, and has no backlash. Eight models are available for stock bores from 1/8 to 1 3/8 in. Ratings per 100 rpm range from 1/40 to 3 hp. Dimensions from 7/8 in. long by 17/32 in. wide to 7 in. long by 5 3/4 in wide.

Olson Industrial Products, Inc., Wakefield, Mass.

Circle No. 227 on Reader Service Card

Flexible shaft couplings

Made of 1/2 in. and 3/8 in. diameter stainless steel flexible core, these couplings will operate at temperatures to 1000 F. Squared stainless

steel sleeves are put on the ends to engage the drive and also to allow for slight changes in length due to varying torques. Total length can be varied to suit the application. Couplings are intended for controls where temperatures are too high to use hydraulic controls.

Stow Mfg. Co., Binghamton, N. Y.

Circle No. 228 on Reader Service Card

Steam hose

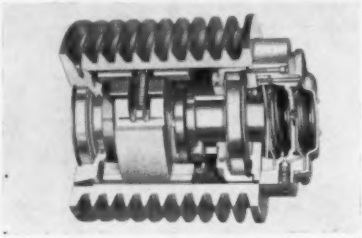
Named White Line Hose, it uses an extruded Teflon innercore, bronze reinforcing wire braid, and solid brass swaged fittings. The braid design allows maximum flexibility with long fatigue life and high burst pressure.

Titeflex Inc., Springfield, Mass.

Circle No. 229 on Reader Service Card

Triple purpose clutch

This unit combines the function of a clutch, adjustable torque selector and variable starting time delay. In



essence it's a centrifugally-operated clutch which may be adjusted both for maximum torque transmitted and for time delay in picking up the driven load. Starting load is completely eliminated. If the driven mechanism is overloaded, the overload is soaked up by the clutch which can be set not to exceed a predetermined torque transmission. Models available for direct connection, for V-belt or flat belt drives, in sizes from 3 to 2000 hp. An integral brake drum can be provided or motor can be reversed to act as brake without damage to the drive.

Olme Precision, Inc., Portsmouth, Ohio.

Circle No. 230 on Reader Service Card

Shaft position encoders

A line of size 18 shaft position-to-digital encoders uses the disc-and-brush principle to convert shaft position data into accurate binary readout. First model in this line is a 13-

bit type with a resolution of 128 counts per input shaft revolution and a full scale capacity of 8192 counts. Identified as Model 773, it weighs 7.6 oz., has a starting torque of less than 0.2 oz.-in. and a moment of inertia of 0.0480 oz.-in. Both serial and parallel readouts are possible.

Librascope Div., General Precision, Inc., Glendale, Calif.

Circle No. 231 on Reader Service Card

Governor controlled brakes

Built for continuous heavy duty, these brakes are said to withstand rotational speeds to 2400 rpm and high air pressures without affecting operation or wear rate on the shoes. The

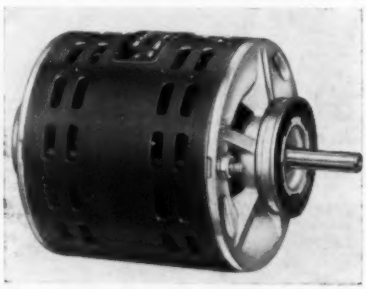
built-in governor control reduces torque output as rpm increases by use of counterweights in the shoe assembly. Company produces air and water cooled models in two different series. Shaft end or flange type mounting available, and permanent or adjustable bases.

Horton Mfg. Co., Inc., Minneapolis, Minn.

Circle No. 232 on Reader Service Card

Small ac motors

Sixteen hp ratings are offered between 1/100 and 1/3 hp for continuous duty at 115 v., 60 cycles.



The line gives a choice of two, four and six pole speeds and capacitor start induction run, split phase, permanent split capacitor, or polyphase design. Motors come in four frame sizes and with round body, resilient, or rigid mountings. The double-end ventilating system uses fans cast integrally with the rotor. Other features include Mylar insulation, double sealed ball bearings, or self-aligning, porous bronze sleeve bearings with felt packing as a lubricant reservoir.

Robbins & Myers, Inc., Springfield, Ohio.

Circle No. 233 on Reader Service Card

Small accelerometers

Three-axis and two-axis models are available. The three-axis model weighs about ½ lb and is approximately 2½ in. in diameter and 2 in. long. It provides information on lin-

ear acceleration along three different axes. The two-axis unit is about 2¼ in. diameter and 2 in. long, and weighs four tenths of a pound. Both accelerometers can be furnished in hermetically-sealed cases with a choice of mountings and connectors. They will withstand —65 F to 180 F, 100% relative humidity, shock of 75 G for 6 milliseconds on any axis and acceleration of 75 G on any axis without damage.

Humphrey, Inc., San Diego, Calif.

Circle No. 234 on Reader Service Card

Torque converter

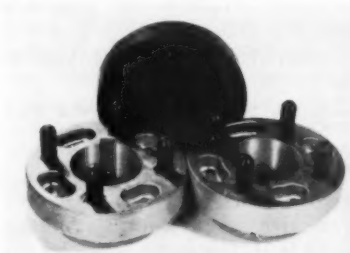
Converter uses air cooling on 10 to 15 hp engines without auxiliary coolant lines, heat exchangers or fans. It has a 9-in. wheel and is rated up to 80 lb-ft. torque input. Stall torque ratio is 1.7 to 1. The unit fits a standard SAE No. 4 flywheel housing, weighs 73 lb. Air flow comes from fins cast on the outside surface of the impeller housing. Internal oil circulation is by pressure differential.

Clark Equipment Co., Automotive Div., Jackson, Mich.

Circle No. 235 on Reader Service Card

Flexible couplings

Two heat-treated aluminum flanges with steel drive pins molded-in are joined by a laminated fabric and synthetic rubber disc. This compound will withstand operating temperatures to 700 F. Heavy-duty discs have woven nylon laminations. Bore sizes from ⅞ to 3⅛ in., hp ratings at 100 rpm from 0.25 to 7.12 hp. All couplings are balanced for operation at or above 3000 rpm, depending on size. No lubrication is required.



Gelder Coupling Div., Van Gelder Mfg., Inc., Oakland, Calif.

Circle No. 236 on Reader Service Card

Instant-reversing motor

Motor features a built-in safety reverse switch actuated by a predetermined resistance. Full power can be switched in either direction. Control is by manual or automatic limit switches with control box connections for electronic signal equipment. Ratios of 20:1 through 30:1 are available with worm gear reduction in the motor end bell. Called the Gear-O-Matic, it's designed for powering doors, ventilators, and similar equipment.

Franklin Electric Co., Inc., Bluffton, Ind.

Circle No. 237 on Reader Service Card

PRODUCTS *continued*

Midget air cylinders

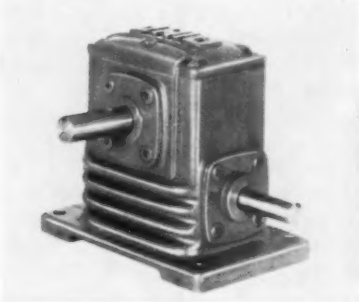
A line of midget cylinders offers 6 models with stroke sizes of 1, 2, 3, 6, 9, 12 in. All models are double-acting, have 1-in. bores, and are suitable for air pressures up to 125 psi. Body, piston, and end plates are brass.

A. Schrader's Sons Div., Scovill Mfg. Co., Brooklyn, N. Y.

Circle No. 238 on Reader Service Card

Fan-cooled reducers

The Series S-13 reducers feature fin and fan cooling and are said to deliver up to 80% more capacity than non-ventilated models of similar size. Unit is worm and gear type for horizontal right angle drive with the worm below. Design advantages are heavy-duty ball bearings in all shafts, shorter center distance between worm and gear and improved heat dissipation. Sizes range from 1.33 in. to 5.5 in. center distance. Horsepower ratings from 1/16 to 18 hp.



The Ohio Gear Co., Cleveland, Ohio.

Circle No. 239 on Reader Service Card

Hydraulic pump

This pump is designed for continuous operation at speeds up to 50,000 rpm and reduced life operation up to 75,000 rpm at discharge pressures to 3000 psi. Pump comes as a complete assembly or in cartridge form for integration into hydraulic power packages. Available in capacities from .2 to 11.5 gpm.

Parker Aircraft Co., Los Angeles, Calif.

Circle No. 240 on Reader Service Card

Thermostat

For use as either an on-off control or a high temperature alarm, this model M-1C thermostat works by differential expansion of solids. It is said to be extremely reliable. Nine models are available, with adjustable temperature ranges of 0-250 to 900-1200F. Electrical rating of the standard switch is 5 amp., 125-250 vac, or 3 amp., 30 vdc. Switch action is single pole, double throw.

Burling Instrument Co., Inc., Chatham N. J.

Circle No. 241 on Reader Service Card

Tube-cooled motors

Tubes form an air-to-air heat exchanger. This protects the motor against moisture, oil vapor, dust, and chemicals. Intended for bad environ-

mental conditions, these motors range up to 2000 hp and are built in standard enclosed or explosion-proof casings. Other features include capsule-type split sleeve bearings and pressure lubricating system with oil level indicators.

Louis Allis Co., Milwaukee, Wis.

Circle No. 242 on Reader Service Card

Limit stop

This instrument is designed to protect servo components which have limited rotational characteristics. Manufactured in BuOrd Sizes #5, #8, #11, #15, #18. (Size #8 shown, has a non-adjustable limit stop range 0° to 12,720°.)

Sterling Precision Corp., Instrument Div., Port Washington, N. Y.

Circle No. 243 on Reader Service Card

Cable ties, clamps

Nylon cable ties and clamps can be installed or released in seconds without special tools. A tiny quick-release lock opens by finger-tip pressure. For wire harnesses from 1/8 in. to 1¾ in. An extra long type is available for bundle diameters up to 3½ in.

Panduit Corp., Midlothian, Ill.

Circle No. 244 on Reader Service Card

High temperature motor

Basic materials of this motor are designed to withstand temperatures from —65 F to 600 F. Windings are nickel-clad copper wire, insulated by impregnated glass. Bearings, stator plating, soldering, etc., have also been treated to maintain reliability at high operating temperatures.

Airborne Accessories Corp., Hillside, N. J.

Circle No. 245 on Reader Service Card

Non-gall slip clutch

The friction plate gear is mounted on a ball bearing which eliminates

galling even after long periods of slippage. A stainless steel bushing between the adjustment clamp and the torque spring protects the other most critical galling point. Friction plate itself is made of Delrin which offers a smoother and more uniform torque. Gears have pitch diameters from 0.750 in. through 2.000 in., with pressure angles of 14½ or 20°.

Dynamic Gear Co., Amityville, N. Y.

Circle No. 246 on Reader Service Card

LITERATURE on drives and components

To get free copies of the following literature, use the Reader Service Cards bound into this issue.

PILLOW BLOCKS . . . of strap-type design are compact, economical and easy to mount. Supplement to Catalog No. 57 includes complete specifications, part numbers, and sizes of three new series—1440, 1540, and 1640. *Randall Graphite Bearings, Inc.*, Lima, Ohio.

Circle No. 300 on Reader Service Card

AXIAL PISTON PUMPS . . . both constant and variable volume models of the 30, 40, and 60 Series pumps are dealt with in 8-page Bulletin 203. Illustrates performance and torque curves and gives a ratings chart for both pumps and fluid motors ranging in maximum pressure from 3500 to 5000 psi. *Denison Engineering Div., American Brake Shoe Co.*, Columbus, Ohio.

Circle No. 301 on Reader Service Card

VARIABLE SPEED DRIVES . . . for capacities to 50 hp and ratios to 5.5:1 are the subject of 6-page Folder 2874. Stepless speed adjustments are made by altering the effective diameter of facing wheels that are connected by a twin-strand, single roll chain. Also illustrates types of assemblies, sizes available, speed variation ratios and selection data. *Link-Belt Co.*, Chicago, Ill.

Circle No. 302 on Reader Service Card

INDUCTION HARDENING . . . for the teeth of large gears increases the strength-hp rating and gear service life. Bulletin No. 100 highlights advantages and shows facilities for this new hardening method. *Philadelphia Gear Corp.*, King of Prussia, Pa.

Circle No. 303 on Reader Service Card

AC MOTOR CATALOG . . . has 56 pages covering complete pricing and dimensional data on motors ranging from ¼ to 200 hp. Describes modifications and contains a special section on motor selection and application. *Sterling Electric Motors, Inc.*, Los Angeles, Calif.

Circle No. 304 on Reader Service Card

SCREW CONVEYOR DRIVES . . . details on a new series for applications in range from ½ to 30 hp, giving output torques to 21,000 lb-in. are presented in Bulletin 7106. Design features and accessories are described. Technical data includes selection information, NEMA motor dimensions and nominal sheave ratios for typical unit ratios and conveyor speeds. *Falk Corp.*, Milwaukee, Wis.

Circle No. 305 on Reader Service Card

ADJUSTABLE-PITCH SHEAVES . . . Bulletin No. 6102 has been revised to provide additional data and new list prices on the SVS sheave. A turn of an adjusting screw gives you the desired pitch diameter with the SVS. Eight pages, letterhead size. *T. B. Wood's Sons Co.*, Chambersburg, Pa.

Circle No. 306 on Reader Service Card

RELAY CATALOG . . . lists over 20 leading relay manufacturers' lines with complete description and prices. A thumb-indexed table of contents speeds your finding of any relay required. *Relay Sales, Inc.*, Chicago, Ill.

Circle No. 307 on Reader Service Card

ADJUSTABLE SPEED DRIVE . . . magnetic drives in ratings from 75 hp to 4000 hp feature a simplified design with few moving parts and provide versatile performance over an automatically regulated 20:1 range. Bulletin No. 3650 gives complete details. *Louis Allis Co.*, Milwaukee, Wis.

Circle No. 308 on Reader Service Card

POLY-V BELT DRIVES . . . are said to provide twice the tractive surface per inch of sheave width of conventional drives. Four-page service booklet outlines design advantages, gives specifications, sheave diameters and condensed hp rating tables. Includes sheave groove dimensions. *Dayton Industrial Products Co.*, Melrose Park, Ill.

Circle No. 309 on Reader Service Card

LUBRICATING EQUIPMENT CATALOG . . . Bulletin X-135 lists a variety of the most widely used equipment for a multitude of oiling jobs. Drawings, specification tables illustrate the data on a complete line of oil cups, oiling systems, dispensers, indicators and chain oilers as well as new developments. *Oil-Rite Corp.*, Manitowoc, Wis.

Circle No. 310 on Reader Service Card

CUSTOM GEAR BROCHURE . . . has 32 pages of illustrated information on facilities for precision manufacture and inspection of made-to-order gearing and gear boxes. *Cincinnati Gear Co.*, Cincinnati, Ohio.

Circle No. 311 on Reader Service Card

SINTERED BRONZE BEARINGS . . . designed to replace miniature precision ball bearings in applications where requirements do not justify the extra cost, are detailed in revised Catalog No. 60-64. Includes a pre-calculated load-speed rating method of finding allowable bearing loads for any size bearing and any shaft speed. *Northfield Precision Instrument Corp.*, Island Park, N. Y.

Circle No. 312 on Reader Service Card

MOTOR SELECTOR . . . contains 8 pages of selection data on a complete motor and generator line. AC motors listed range from 1/40 to 300 hp in a wide variety of voltages, speeds, mountings and enclosures. *Howell Electric Motors Co.*, Howell, Mich.

Circle No. 313 on Reader Service Card

MAGNETIC CLUTCHES . . . and precision differentials from stock are offered in a complete line in Catalog No. 63. Clutches are manufactured to MIL-E requirements and differentials to MIL-E 5272C. *Sterling Precision Instrument Corp.*, Long Island, N. Y.

Circle No. 314 on Reader Service Card

DUAL TORQUE LOCKING . . . and positioning device is described in a 12-page bulletin. Device can drive, position, over-run and backstop in clockwise and counter-clockwise directions. Also positively prevents torque feedback from either direction. Specifications and industrial applications included. *Formsprag Co.*, Warren, Mich.

Circle No. 315 on Reader Service Card

HIGH FREQUENCY ALTERNATORS . . . and converters are detailed in Bulletin 515-A. Illustrations and selection tables cover 9 basic models from 1 to 7.5 KVA and 360 to 3300 cycles. Also covers 2 types of converters in 4 ratings from 2.5 to 10 KW and 6 frequencies from 120 to 420 cycles. *Robbins & Meyers, Inc.*, Springfield, Ohio.

Circle No. 316 on Reader Service Card

LAMINATED PLASTICS . . . eight-page brochure reviews facilities for fabricating laminated plastic parts. Stresses specialized machines and tools and ability to furnish almost any part from customers print. *Synthane Corp.*, Oaks, Pa.

Circle No. 317 on Reader Service Card

MASTER CATALOG . . . lists over 50,000 components that are available from stock, including miniature precision gears cut to center distance. Also covers differentials, speed reducers and gearheads, and transmissions with up to 15 available speed ranges from 3.3 rpm to 7812 rpm. Lists all prices. Catalog #F-128. *Dynamic Gear Co.*, Amityville, N. Y.

Circle No. 318 on Reader Service Card

INDUSTRIAL CRANKSHAFTS . . . can be ground and honed while in place. Folder outlines methods and gives charts for three different types of crankshafts so that exact measurements can be listed in advance to speed-up service. *Golten Marine Co., Inc.*, New York, N. Y.

Circle No. 319 on Reader Service Card

ELECTRIC BRAKES . . . and clutches in a complete company line are covered in a product brochure. Describes several clutch, brake, and clutch-brake applications, outlines specific operating advantages and includes torque ratings and package dimensions. Three color illustrations. *Warner Electric Brake & Clutch Co.*, Beloit, Wis.

Circle No. 320 on Reader Service Card

VARIABLE SPEED DRIVES . . . for fractional hp applications are featured in a 16-page catalog. Operating points and installation suggestions are illustrated with numerous diagrams and charts. Complete details on the new 400 Series drives. *The Zero-Max Co.*, Minneapolis, Minn.

Circle No. 321 on Reader Service Card

Circle No. 38 on Reader Service Card

Circle No. 5 on Reader Service Card

Circle No. 20 on Reader Service Card

ULTRA LOW TORQUE BEARINGS . . . in sizes from ½ in. to 1½ in. OD use an electromagnetically-powered ball assembly to obtain very low restraining torque characteristics. Information on dimensions, size and design features contained in 2-page data sheet D-3. *The Barden Corp.*, Danbury, Conn.

Circle No. 322 on Reader Service Card

MAGNETIC PARTICLE CLUTCHES . . . ranging in capacity from 2.5 oz in. to 1900 lb in. are the subject of this 16-page brochure. Illustrations, installation drawings and performance curves present the details on 10 different series of clutches and their possible uses. *Lear, Inc.*, Grand Rapids, Mich.

Circle No. 323 on Reader Service Card

MINIATURE GEARMOTORS . . . Bulletin 135 describes ⅞ in. diameter permanent magnet precision motors with integral planetary gear reducers in 21 ratios from 3.82:1 to 36873:1. *Globe Industries, Inc.*, Dayton, Ohio.

Circle No. 324 on Reader Service Card

AMPLISTAT REACTORS . . . for motor drives are included in a 20-page bulletin. Reactors apply power to the armature of a dc motor. Pamphlet gives a selection guide. *General Electric Co.*, Schenectady, N. Y.

Circle No. 325 on Reader Service Card

MASTER STANDARDS MANUAL . . . of precision instrument components is available at no charge to department heads. Over four hundred loose-leaf pages, in a leather bound ring binder. Requests for the book must be in writing on company stationery. It will be distributed personally by PIC sales engineers. *PIC Design Corp.*, East Rockaway, N. Y.

SHAFT POSITION ENCODER . . . a 12-page brochure has specifications for 13-bit, 8-bit, and incremental encoders. Operating principle of a new magnetic readout is also described. *ASCOP Div., Electro-Mechanical Research, Inc.*, Princeton, N. J.

Circle No. 326 on Reader Service Card

NEEDLE BEARINGS . . . have spherical end-rollers said to increase bearing life and load capacity. Bulletin S-103 has specifications. Bulletin No. 57 illustrates standard and special ball and roller bearings of various types. *Kaydon Engineering Corp.*, Muskegon, Mich.

Circle No. 327 on Reader Service Card

DRY FILM LUBRICANT . . . known as "Poxylube" needs no surface pretreatment. A 4-page brochure explains the principles of this resin-bonded lubricant. *Poly Chem, Inc.*, Indianapolis. Ind.

Circle No. 328 on Reader Service Card

CONTROL UNITS . . . for tension and torque in webs and filaments, edgeguide installations, and electric or pneumatic eye controls. Six-page brochure gives details. *Web Controls Corp.*, West Englewood, N. J.

Circle No. 329 on Reader Service Card

STEAM TURBINE . . . for requirements up to 1000 hp can be adapted to natural gas expansion and to other gases, such as freon. Bulletin 2001 covers performance details. *Dean Hill Pump Co.*, Indianapolis, Ind.

Circle No. 330 on Reader Service Card

CYLINDRICAL ROLLER BEARINGS . . . in a wide variety of types and sizes, together with spherical bearings, are featured in 12-page Bulletin No. 114. Gives dimensions, load and application information. *Hoover Ball and Bearing Co.*, Ann Arbor, Mich.

Circle No. 331 on Reader Service Card

MAGNETIC CONTACTORS, STARTERS . . . 20-page bulletin GEA-7020 gives application, installation, and maintenance information for NEMA sizes 0-5. *General Electric Co.*, Schenectady, N. Y.

Circle No. 332 on Reader Service Card

ACTUATORS . . . are built to customer specifications. Catalog 2-60-4 gives details and describes instrument drives, tachometers, geared adapters, gear boxes, flexible shafts, and clutches which are available. *Actuator Products Div., Geartronics Corp.*, Woburn, Mass.

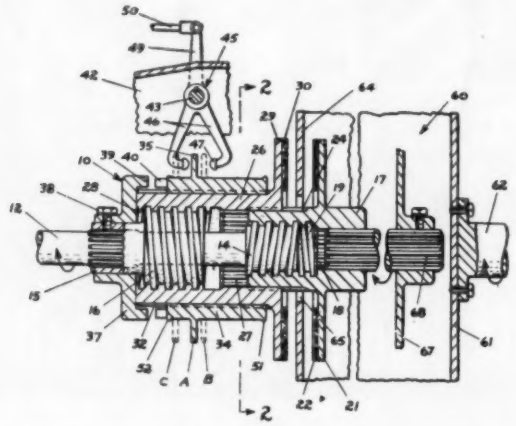
Circle No. 333 on Reader Service Card

PATENTS

Clutch

U.S. Patent No. 2,893,524; Peter Ferrier, Vancouver, British Columbia, Canada.

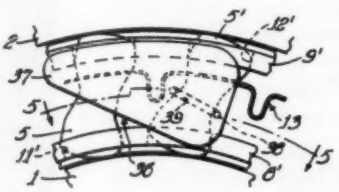
For use with a fluid coupling, this clutch has an output shaft with opposed threads, an inner clutch sleeve engaging one of the opposed threads, and an outer sleeve which can slide but not rotate mounted on the inner sleeve. The outer sleeve engages the second set of opposed threads. Inner sleeve is connected to the driven member. Inner and outer sleeves have a clutch member connected to them. These members are on either side of a clutch element on the driving member. Rotation of the output shaft within the sleeves causes clutch members on the sleeves to move toward and engage the driving clutch element.



One-way clutch

U. S. Patent No. 2,917,145; Ernest A. Ferris, Elmhurst, Ill., and Bertram A. Fulton, Glen Ellyn, Ill., assignors to Borg-Warner Corp., Chicago, Ill.

This overrunning clutch incorporates centrifugal weights with arms attached to certain of the sprags.



The centrifugal weights disconnect these sprags during certain overrunning conditions.

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202	208	214	220	226	232	238	244	250	256	262	268
203	209	215	221	227	233	239	245	251	257	263	269
204	210	216	222	228	234	240	246	252	258	264	270
205	211	217	223	229	235	241	247	253	259	265	271

FREE LITERATURE

300	306	312	318	324	330	336	342	348
301	307	313	319	325	331	337	343	349
302	308	314	320	326	332	338	344	350
303	309	315	321	327	333	339	345	351
304	310	316	322	328	334	340	346	352
305	311	317	323	329	335	341	347	353

August 1960 Circle item numbers for additional information about products described and advertised in this issue.

ADVERTISEMENTS

1	13	25	37	49	61	73	85	97	109	121	133	145
2	14	26	38	50	62	74	86	98	110	122	134	146
3	15	27	39	51	63	75	87	99	111	123	135	147
4	16	28	40	52	64	76	88	100	112	124	136	148
5	17	29	41	53	65	77	89	101	113	125	137	149
6	18	30	42	54	66	78	90	102	114	126	138	150
7	19	31	43	55	67	79	91	103	115	127	139	151
8	20	32	44	56	68	80	92	104	116	128	140	152
9	21	33	45	57	69	81	93	105	117	129	141	153
10	22	34	46	58	70	82	94	106	118	130	142	154
11	23	35	47	59	71	83	95	107	119	131	143	155
12	24	36	48	60	72	84	96	108	120	132	144	156

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TITLE ____________

COMPANY ____________

PRODUCT MFG. ____________

ADDRESS ____________

CITY ____________ ZONE ______

STATE ____________

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NEW PRODUCTS

200	206	212	218	224	230	236	242	248	254	260	266
201	207	213	219	225	231	237	243	249	255	261	267
202	208	214	220	226	232	238	244	250	256	262	268
203	209	215	221	227	233	239	245	251	257	263	269
204	210	216	222	228	234	240	246	252	258	264	270
205	211	217	223	229	235	241	247	253	259	265	271

FREE LITERATURE

300	306	312	318	324	330	336	342	348
301	307	313	319	325	331	337	343	349
302	308	314	320	326	332	338	344	350
303	309	315	321	327	333	339	345	351
304	310	316	322	328	334	340	346	352
305	311	317	323	329	335	341	347	353

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